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FORCE MANAGEMENT
AND PERSONNEL

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FOREWORD

This Manual is issued under the authority of and in accordance with DoD Instruction 4145.26, "DoD Contractors' Safety Requirements for Ammunition and Explosives," July 19, 1985. The Manual provides safety standards common to DoD and private industry ammunition and explosives (A&E) operations and facilities. The application of this Manual to A&E contracts is required by DoD FAR Supplements. Additional A&E or other related safety requirements may be included within the contract by the purchasing activity as determined necessary.

This revision has included basic principles of A&E safety, reduces mandatory requirements to the minimum, excludes safety requirements of other Federal regulatory agencies, and provides sufficient information to enable the contractor to make appropriate and reliable decisions affecting his or her facilities and operations. The methods of compliance are the responsibility of the contractor.

Questions on interpretation of any aspect of this Manual or recommendations for revisions by the contractor shall be submitted to the contractor's assigned administrative contracting officer (ACO) for further review and processing.

This Manual applies to the Office of the Secretary of Defense (OSD), the Military Departments, the Organization of the Joint Chiefs of Staff, the Unified and Specified Commands, and the Defense Agencies (hereafter referred to collectively as "DoD Components").

This Manual is effective immediately, and is mandatory for use by all DoD Components specified in DoD Instruction 4145.26.

Forward recommended changes to this Manual through appropriate channels to:

Commander
US Army Armament, Munitions, and Chemical Command
ATTN: AMSMC-JS
Rock Island, IL 61299-6000

DoD Components may obtain copies of this Manual through their own publications channels. Other Federal agencies and the public may obtain copies from the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Chapman B. Cox
Assistant Secretary of Defense
(Force Management and Personnel)

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DOD CONTRACTORS'
SAFETY MANUAL FOR
AMMUNITION AND EXPLOSIVES

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TABLES

DEFINITIONS

The following are descriptions of terms and phrases commonly used in conjunction with ammunition, explosives, and other dangerous materials. These are listed to provide a degree of uniformity of description in the use of technical information throughout these standards.

1. Aboveground Magazines. Any type of magazines above ground other than standard or nonstandard earth-covered types of magazines.

2. Administration Area. The area in which administrative buildings that function for the installation as a whole are located, excluding those offices located near and directly serving components of explosives storage and operating areas.

3. Aircraft Parking Area. Any area set aside for parking aircraft not containing explosives.

4. Ammunition and Explosives. As used herein, includes (but is not necessarily limited to) all items of ammunition; propellants, liquid and solid; high explosives; guided missiles; warheads; devices; pyrotechnics; chemical agents; components thereof; and substances associated therewith presenting real or potential hazards to life and property.

5. Ammunition and Explosives Aircraft Cargo Area. Any area specifically designated for the following:

a. Aircraft loading or unloading of transportation configured ammunition and explosives.

b. Parking aircraft loaded with transportation configured ammunition and explosives.

6. Ammunition and Explosives Area. An area specifically designated and set aside from other portions of an installation for the development, manufacture, testing, maintenance, storage, or handling of ammunition and explosives.

7. Auxiliary Building. Any building accessory to or maintained and operated to serve an operating building, line, plant, or pier area. Explosive materials are not present in an auxiliary building (examples: power plants and chargehouses, paint and solvent lockers, and similar facilities).

8. Barricade. An intervening barrier, natural or artificial, of such type, size, and construction as to limit in a prescribed manner the effect of an explosion on nearby buildings or exposures.

9. Blast Impulse. The product of the overpressure from the blast wave of an explosion and the time during which it acts at a given point (that is, the area under the positive phase of the overpressure VS time curve).

10. Blast Overpressure. The pressure, exceeding the ambient pressure, manifested in the shock wave of an explosion.

11. Change House. A building provided with facilities for employees to change to and from work clothes. Such buildings may be provided with sanitary facilities, drinking fountains, lockers, and eating facilities.

12. Classification Yard. A railroad yard used for the receiving, dispatching, classifying, and switching of cars.

13. Compatibility. Ammunition and explosives are considered compatible if they may be stored or transported together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

14. Deflagration. A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction and temperature, and may cause transition into a detonation.

15. Demilitarize. To disarm, neutralize, and accomplish any other action required to render ammunition and explosives innocuous or ineffectual for military use.

16. Detonation. A violent chemical reaction within a chemical compound or mechanical mixture evolving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium forming a propagating shock wave that is originally of supersonic velocity. A detonation, when the material is located on or near the surface of the ground, normally is characterized by a crater.

17. Dud. Explosive munition that is not armed as intended, or that has failed to function after being armed.

18. Establishment. Any plant, works, facility, installation, or other activity.

19. Explosion. A chemical reaction of any chemical compound or mechanical mixture that, when initiated, undergoes a very rapid combustion or decomposition releasing large volumes of highly heated gases that exert pressure on the surrounding medium. Also, a mechanical reaction in which failure of the container causes the sudden release of pressure from within a pressure vessel; for example, pressure rupture of a steam boiler. Depending on the rate of energy release, an explosion can be categorized as a deflagration, a detonation, or a pressure rupture.

20. Explosive. Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

21. Explosives Facility. Any structure or location containing ammunition and explosives.

22. Firebrand. A projected burning or hot fragment whose thermal energy is transferred to a receptor.

23. Fire-Resistive. Applies to generally combustible materials or structures that have been treated or have surface coverings designed to retard ignition or fire spread.

24. Firewall. A wall of fire-resistive construction designed to prevent the spread of fire from one side to the other. A firewall also may be termed a "fire divison wall."

25. Flame-Resistant. Applies to combustible materials, such as clothing, which have been treated or coated to decrease their burning characteristics.

26. Flammable. Combustible. A flammable material is one that is ignited easily and burns readily.

27. Fragmentation. Breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place. Fragments may be complete items, subassemblies, pieces thereot, or pieces of equipment or buildings containing the items.

28. Hangfire. Temporary failure or delay in the action of a primer, igniter, or propelling charge.

29. Hazard Analysis. The logical, systematic examination of an item, process, condition, facility, or system to identify and analyze the probability, causes, and consequences of potential or real hazards.

30. High Explosive Equivalent or Explosive Equivalent. The ratio of the weight of TNT to that of another explosive when both quantities produce equivalent blast effects at the same distance from their detonations. The ratio is usually expressed as a percent.

31. Holding Yard. A location for groups of railcars, trucks, or trailers used to hold ammunition and explosives for interim periods before storage or shipment.

32. Hypergolic. The term used to describe the self-ignition of certain fuels and oxidizers upon contact with each other.

33. Inhabited Building. A building or structure, other than an operating building, occupied in whole or part by human beings; or a building or structure when people customarily assemble, such as a church, schoolhouse, railroad station and similar transportation facilities, store, theater, or factory, inside or outside the establishment.

34. Inspection Station. A designated location at which trucks and railcars containing ammunition and explosives are inspected.

35. Interchange Yard. An area set aside for the exchange of railroad cars or vehicles between the common carrier and establishment.

36. Intraline Distance. The distance to be maintained between any two operating buildings and sites within an operating line, at least one of which contains or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building will not be less than the intraline distance required for the quantity of explosives contained in the service magazine.

37. Launch Pads. The load-bearing base, apron, or platform upon which the rocket, missile, or space vehicle and its launcher are positioned.

38. Liquid Propellant(s). Liquid and gaseous substances (fuels, oxidizers, or monopropellants) used for propulsion or operation of missiles, rockets, and related devices (see table 7-1).

39. Loading Docks. Facilities structure, or paved areas, designed and installed for transferring ammunition and explosives between any two modes of transportation.

40. Magazine. Any building or structure, except an operating building, used for the storage of ammunition and explosives. The types, general specifications, and siting requirements of various magazines for ammunition and explosives follow:

a. Army Igloo Magazines

(1) Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of the Army Office of Chief of Engineers drawings 652-680 through 652-693, dated December 27, 1941, as revised March 14, 1942; and drawings 33-15-58 (atomic blast resistant), 33-15-61, and 33-15-74, for all quantities of explosives up to 500,000 pounds.

(2) Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of paragraph 40.a.(1), above, for quantities of explosives up to 250,000 pounds.

b. Navy Arch-Type Magazines

(1) Magazines constructed according to Navy drawings 357428 through 357430, dated August 9, 1944, and modified in accordance with Naval Facilities Engineering Command (NAVFAC) drawing 626739, dated March 19, 1954, or new magazines constructed according to NAVFAC drawings 627954 through 627957, 764597, 793747, 658384 through 658388, 724368, 751861, 764596, and 793746, for all quantities of explosives up to 500,000 pounds.

(2) Magazines constructed in accordance with NAVFAC drawings 649602 through 649605, 793748, and 803660, for all quantities of explosives up to 250,000 pounds.

c. Earth-Covered, Corrugated Steel, Arch-Type Magazine. Structures at least equivalent in strength to those shown on Army Office of Chief of Engineers (OCE) drawings numbered AW 33-15-63, dated March 5, 1963; AW 33-15-64, dated May 10, 1963; 33-15-65, dated January 10, 1963; NAVFAC drawings 1059128-30, 1059132, 1069906, or 1355460-61, for all quantities of explosives up to 500,000 pounds.

41. Mass Detonating Explosives. High explosives, black powder, certain propellants, certain pyrotechnics, and other similar explosives, alone or in combination, or loaded into various types of ammunition or containers, most of which can be expected to explode virtually instantaneously when a small portion is subjected to fire, to severe concussion or impact, to the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without. Such an explosive will normally cause severe structural damange to adjacent objects. Explosive propagation may occur immediately to other items of ammunition and explosives stored sufficiently close to and not adequately protected from the initially exploding pile with a time interval short enough so that two or more quantities must be considered as one for quantity/distance (Q/D) purposes.

42. Maximum Credible Event (MCE). In hazards evaluation, the MCE from a hypothesized accidental explosion, fire, or agent release is the worst single event that is likely to occur from a given quantity and disposition of ammunition and explosives. Event must be realistic with a reasonable probability of occurrence, considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

43. Military Pyrotechnics. Ammunition manufactured specifically for use as signals, illuminants, and like items.

44. Misfire. Failure of a component to fire or explode as intended.

45. Navigable Streams. Those parts of streams, channels, or canals capable of being used as highways of commerce over which trade and travel are or may be conducted, excluding streams that are not navigable by barges, tugboats, and other large vessels, unless they are used extensively and regularly for the operation of pleasure boats.

46. NEW. Net Explosive Weight, expressed in pounds.

47. Nitrogen Padding (or Blanket). Filling the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical therein and to avoid formation of a flammable atmosphere above the liquid. Nitrogen padding (or blanket) also means maintaining a nitrogen atmosphere in or around an operation, piece of equipment, etc.

48. Noncombustible. Not burnable.

49 Operating Building. Any structure, except a magazine, in which operations pertaining to manufacturing, processing, handling, loading, or assembly of ammunition and explosives are performed.

50. Operating Line. A group of buildings, facilities, or related work stations so arranged as to permit performance of the consecutive steps in the manufacture of an explosive or in the loading, assembly, modification, and maintenance of ammunition.

51. Operational Shield. A barrier constructed at a particular location or around a particular machine or operating station to protect personnel, material, or equipment from the effects of a possible localized fire or explosion. Operational shields, when properly designed in accordance with MIL-STD 398 (reference (a)) should protect personnel and assets from thermal, pressure, and fragmentation hazards resulting from an accidental or intentional detonation and deflagration of ammunition or explosives. Existing reinforced concrete walls built to resist the effects of accidental explosions and designed and built in accordance with requirements applicable at the time of construction may be used as operational shields, with the following guidance as a minimum requirement:

a. A 12-inch reinforced concrete wall provides adequate protection for disassembly operations involving an item containing 15 pounds TNT equivalent or less of high explosives when the nearest part of the item is at least 3 feet from the wall and the item is 2 feet from the floor. Care shall be taken to use appropriate equivalence data for close-in effects. Explosives characterized by greater brisance than that of TNT may have very high equivalencies at small distances from the explosives. When equivalence data is not available, existing 12-inch reinforced concrete walls may be used for operational shields for protection from items containing not more than 6 pounds of high explosives.

b. A 30-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 50 pounds TNT equivalent of high explosives. The same separation distance as stated in paragraph 51.a., above, applies. When equivalence data is not available, a 30-inch wall may be used for an operational shield for protection from items containing not more than 20 pounds of high explosives.

c. A 36-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 70 pounds TNT-equivalency of high explosives. The separation distance as stated in paragraph 51.a., above, applies. When equivalence data is not available, a 36-inch wall may be used for an operational shield for protection from items containing not more than 20 pounds of high explosives.

52. Prohibited Area. A specifically designated area at airfields, seadromes, or heliports in which all ammunition and explosives facilities are prohibited.

53. Protected. Terrain or artificial barrier interposed to prevent fragments from a propellant facility from endangering inhabited buildings and other exposures.

54. Public Highway. Any street, road, or highway used by the general public for any type of vehicular travel.

55. Public Traffic Route. Any public street, road (including any on an establishment or military reservation), highway, navigable stream, or passenger railroad that is routinely used for through traffic by the general public.

56. Pyrotechnic Material. The explosive or chemical ingredients, including powdered metals, used in the manufacture of military pyrotechnics.

57. Quantity/Distance (Q/D). The quantity of explosives material and distance separation relationships providing defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q/D tables. Separation distances afford less than absolute safety. Greater distances than those shown in the tables shall be used wherever practicable.

58. Renovation. That work performed on ammunition, missiles, or rockets to restore them to a completely serviceable condition; usually involves the replacement of unserviceable or outmoded parts.

59. Restricted Area. Any area, normally fenced, from which personnel, aircraft, or vehicles, other than those required for operations, are excluded for reasons of safety.

60. Runway. Any surface on land designated for aircraft takeoff and landing operations, or a lane of water designated for takeoff and landing operations of seaplanes.

61. Service Magazine. An auxiliary building of an operating line used for the intermediate storage of explosives materials. The amount of explosives normally is limited to a minimum consistant with safe, efficient production.

62. Solid Propellant. Explosives compositions used for propelling projectiles and rockets and to generate gases for powering auxiliary devices.

63. Standard Igloo Magazine. An earth-covered, arch-type magazine, with or without a separate door barricade, constructed according to an approved standard drawing.

64. Static Test Stand. Locations whereon liquid propellant engines or solid propellant motors are tested in place.

65. Substantial Dividing Wall. An interior wall designed to prevent simultaneous detonation of explosives on opposite sides of the wall. However, such walls may not prevent propagation (depending on quantities and types of explosives involved).

a. Substantial dividing walls are one way of separating explosives into smaller groups to minimize the results of an explosion and allow a reduction in Q/D. These walls do not protect personnel near the wall from high explosives because the spalling of wall surface opposite the explosion source may form dangerous secondary fragments.

b. Reinforced concrete-type walls may vary in thickness, but will be at least 12 inches thick. At a minimum, both faces will be reinforced with rods at least 1/2 inch in diameter. The rods will be spaced not more than 12 inches on centers horizontally and vertically, interlocked with the footing rods and secured to prevent overturning. Rods on one face will be staggered with regard to rods on the opposite face and should be approximately 2 inches from each face. Concrete should have a design compressive strength of 2,500 psi or more. The capability to prevent simultaneous detonation is based on a limit of 425 net pounds of mass-detonating explosives. All storage plans and Q/D

calculations shall be based on the total quantity of mass-detonating explosives on both sides of a dividing wall when the quantity of either side exceeds 425 pounds. Explosives should be 3 feet or more from the wall.

c. Retaining walls filled with earth or sand must be at least 5 feet wide, with earth or sand packed between concrete, masonry, or wooden retaining walls.

66. Suspect Truck and Car Site. A designated location for placing trucks and railcars containing ammunition or explosives that are suspected of being in hazardous condition. These sites also are used for trucks and railcars that may be in a condition that is hazardous to their contents.

67. Taxiway/Taxilane. Any surface designated as such in the basic airfield clearance criteria specified by a DoD Component publication or Federal Aviation Administration Regulation (reference (b)).

68. Waiver. Written authority that provides a temporary exception, permitting deviation from mandatory requirments of this Manual. It generally is granted for short periods of time pending cancellation as a result of termination of scheduled work commitments or correction of the waived conditions.

REFERENCES

(a) MIL-STD 398, "Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance" (current edition)
(b) Federal Aviation Administration Regulation, "Objects Affecting Navigable Airspace" (14 CFR 77)
(c) DoD Directive 6055.9, "The DoD Explosives Safety Board," November 25, 1983
(d) TM 5-1300, AFM 88-22, and NAVFAC P-397, "Structures to Resist the Effects of Accidental Explosions," June 1969
(e) TB 700-2, NAVSEA Instruction 8020.8, T011A-1-47, DLAR 8220.1, September 1982
(f) Joint Services Safety and Performance Manual, 1972
(g) WR-50, Naval Weapons Requirements, Warhead Safety Tests, Minimum for Air, Surface and Underwater Launched Weapons (excluding mine and nuclear warheads), CODE IDENT 10001, Department of the Navy, Bureau of Naval Weapons, February 13, 1964.
(h) NAVAIR 00-130-ASR-2-1, Joint Munitions Effectiveness Manual, "Air-to-Surface Joint Service Test Procedures for Bombs and Bomblets," December 1968
(i) National Fire Protection Association (NFPA), National Fire Codes/Standards 13, 15, 33, 48, 63, 70, 77, and 491M (current Codes/Standards)
(j) National Electric Code (NEC) (current edition)
(k) Federal Aviation Administration Handbook (current edition)

CHAPTER 1

INTRODUCTION

A. PURPOSE

This Manual provides reasonable and standardized A&E safety principles, methods, practices, requirements, and information for contractual work or services performed in connection with contracts involving A&E. Understanding and compliance with the applicable requirements of this Manual and additional safety requirements of the contract, if any, should minimize the potential for mishaps that could interrupt DoD operations or delay production delivery dates, adversely impact upon DoD production capabilities, damage or destroy DoD material/equipment, cause injury to DoD personnel, or endanger the general public. Therefore, adherence to the Manual's standards and principles will support DoD mission accomplishment, provide a safe environment for contract work and enhance cooperation and assistance from DoD personnel.

B. APPLICABILITY

This Manual applies to contractors performing work or services on DoD contracts, subcontracts, purchase orders, or other purchasing methods for ammunition or explosives as defined within the contract. These safety standards are minimum requirements and shall be accepted as final authority over applicable A&E contractor operations and their locations, whether inside or outside of the establishment.

C. MANDATORY AND ADVISORY STANDARDS

The standards contained in this Manual that use the terms "shall," "must," and "will" are considered mandatory requirements. Waivers to these requirements may be authorized by the procuring contracting officer (PCO) as explained in paragraph E.1. and 2., below. The terms "should" and "may" are advisory when used in this Manual. When advisory provisions are not met, adverse consequences may develop, becoming proximate causes of A&E mishaps.

D. RESPONSIBILITIES

The contractor or subcontractor is responsible for adhering to the following:

1. Complying with the requirements of this Manual and any other safety requirements contained within the contract.

2. Developing and implementing a demonstrable safety program (in addition to operational procedures) that ensures mishap prevention in contractural activities.

3. Designating qualified individuals to administer and implement this safety program.

4. Providing information to the Administrative Contracting Officer (ACO) pertaining to subcontractors retained for A&E work. Providing advice and assistance to subcontractors during their work performance.

5. Conducting mishap investigations in accordance with, but not limited to, provisions of this Manual.

E. COMPLIANCE WITH MANDATORY STANDARDS

1. During preaward safety surveys, violations of mandatory standards contained in this Manual must be resolved. The contractor may choose to correct the deficiencies immediately, submit a written letter of intent to correct the deficiencies (which will become binding if awarded the contract), or request acceptance of specifically identified existing conditions/facilities by the purchasing activity.

2. When the contractor cannot comply with the mandatory safety provisions of the contract, the contractor will develop and submit a request for a waiver through the ACO to the Procuring Contracting Officer (PCO) for final determination. The request will contain complete information concerning the standards violated, actions planned to minimize the hazard, and a proposed date of completed corrective action to eliminate the stated noncompliance.

F. SITE AND CONSTRUCTION PLANS

1. Development and submission of site plans, modifications, construction, and utilities drawings pertaining of DoD-owned facilities will be processed in accordance with the requirements of DoD Directive 6055.9 (reference (c)), as implemented by the applicable Military Service requirements.

2. For contractor-owned, contractor-operated (COCO) facilities, the contractor shall submit, to the ACO, site and construction plans for all new construction or major modification of facilities for ammunition and explosive activities and for the facilities that may be exposed to A&E hazards if improperly located. The contractor will not begin construction/modification of proposed facilities until receiving site and construction plan acceptance from the ACO.

3. Modification or rehabilitation plans for existing facilities that are essentially minor, introduce no new hazards, and do not increase the net explosive capacity for which the facility was designed or sited, need not be submitted. (The ACO will make the final determination as to whether a site plan is necessary.)

4. Site plans shall contain the following:

a. Drawings scaled at not less than 1 inch to equal 400 feet. Smaller-scale drawings may sometimes be necessary to reflect certain distance and structure relationships within the area surrounding a given project. In such instances, reductions in scale are acceptable.

b. Indication of distances between the facility and other installation facilities, the installation boundary, public railways, and public highways, including power transmission and utility lines.

c. Identification of all other facilities within inhabited building distance of the facility, with a brief description of the nature of occupancy of the former.

d. Descriptions of A&E items or hazardous materials to be in the facilities, that is, bombs, rockets, artillery ammunition, liquid propellants, or other items requiring protective measures in accordance with this Manual.

e. Indication of net explosives weight, number of units and class(es) of ammunition, explosives, liquid and solid propellants, or other hazardous materials proposed for the facility, including a breakdown by room or bay.

f. Indication of net explosives weight, number of units and class(es) of ammunition, explosives, liquid and solid propellants, or other hazardous materials in facilities located within inhabited distance of the facility.

5. Site and construction plans will contain the information in paragraphs F.4.a. through f., above, and the following:

a. Anticipated personnel limits for the new or modified facility, including a breakdown by room or bay, when appropriate.

b. General details regarding dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, A&E waste disposal systems, lightning protection systems, static grounding systems, process equipment, and auxiliary support structures, as well as general materials of construction.

c. Information relative to the types and arrangment of explosive operations or chemical processing equipment.

d. A topographical map with appropriate contours when terrain features are considered to constitute natural barricading, or when topography otherwise influences layout.

e. Explanation of any deviations from pertinent safety standards due to local conditions.

G. PREAWARD SAFETY SURVEY

1. When A&E materials and operations are involved in a contract, mishaps could adversely effect production capability, production assets, or long lead time products/services essential to DoD program milestones; therefore the contractor's capability and preparedness must be evaluated. Preaward safety surveys will be conducted by DoD safety personnel.

2. During the preaward safety survey, the contractor, at a minimum, must be prepared to assist by providing the following for review:

a. Site plans conforming to the requirements of paragraphs F.4.a. through f., above.

b. Safety program, organization, and training.

c. Fire prevention program and available firefighting resources, including local agreements.

d. Description of facilities including size, construction design and materials, fire resistive capability, utilities, and current compliance with existing building regulations and codes.

e. Operational compliance with applicable Federal, state, and local requirements. All operations that may adversely affect the proposed schedule of work or related structures if a mishap occurs, including similar A&E operations, will be reviewed.

f. Required licenses or capability to obtain those required to perform proposed contract work.

g. Past safety history, including reports of safety surveys by Federal, state, or local safety, fire prevention, insurance, or other authorities; current status of waivers or exemptions issued by Federal, state, or local authorities; mishap experience.

h. A&E collection and disposal systems and procedures. The contractor may wish to request specific clarification of A&E residue/reject item disposition at this time.

i. Hazard analysis, as appropriate.

H. PREOPERATIONAL SURVEY

After contract award, Government review and evaluation of the facilities/operations may be necessary before startup of production/services. The contractor will therefore contact the ACO to offer an opportunity for a preoperational review by authorized DoD personnel.

CHAPTER 2

MISHAP INVESTIGATION AND REPORTING

A. GENERAL

This chapter sets forth requirements to be followed for mishaps involving ammunition and explosives.

B. REPORTING CRITERIA

All mishaps involving ammunition and explosives that result in one or more of the following shall be investigated by the contractor and reported to the ACO.

1. One or more fatalities.

2. One or more lost-workday cases (disabling injury).[1]

3. Ten or more nonfatal injuries without lost workdays.[1]

4. Damage to Government property exceeding $10,000.

5. Delay in delivery schedule of Government production exceeding 24 hours.

6. Mishaps that are reportable in accordance with specific contractual requirements other than the above.

7. Any mishap that may degrade operational/production capability or likely to arouse unusual media interest because of exceptional circumstances.

NOTE: Based upon the seriousness of the mishap and/or the criticality of the munitions/explosives involved, the ACO may determine that an additional, more comprehensive mishap investigation and report is desired.

C. MISHAP SCENE

In the event of an ammunition or explosives mishap, the contractor shall implement emergency procedures, such as controlling the spread of fire and attending to the injured. Concurrently, the contractor shall secure the scene of the mishap that led to one or more of the problems described in paragraph B., above. This will keep unauthorized persons away from the mishap scene for their protection, and will allow for preservation of evidence for the mishap investigation.

D. TELEPHONIC REPORT

The contractor shall telephonically report any mishap described in paragraph B., above, to the ACO as soon as practicable, but not later than 3 hours after the incident. The format provided in paragraph E., below, will serve as a guide for the telephonic report.

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[1] As defined in American National Standards Institute Safety Standard Z16.4, "Uniform Recordkeeping for Occupational Injuries and Illnesses," in effect on the date of the solicitation.

E. WRITTEN REPORT

1. The contractor shall develop and submit to the ACO a written mishap report by the end of the second working day after the mishap occurrence. At a minimum, this written report shall include the following:

a. Contractor's name and location.

b. Date, local time, and plant/facility location of the accident.

c. Category of accident (explosion, fire, etc.).

d. Contract, subcontract, or purchase order.

e. Item nomenclature, hazard classification, lot number.

f. Description of mishap events.

g. Description of injuries/fatalities.

h. Description of property damage and approximate damage cost.

i. Quantity of explosives involved (pounds, units, rounds, etc.).

j. Cause(s), known or probable.

k. Corrective action taken or planned.

l. Effect on production.

m. Name, title or position, and phone number of person submitting report.

n. Remarks.

2. Information not furnished in the initial written report shall be provided to the ACO within 30 days of the mishap.

F. ON-SITE GOVERNMENT ASSISTANCE

To help determine the cause or causes of the mishap, Government representatives may monitor the contractor's mishap investigation on-site. Additional investigation or reporting may be required by the PCO.

G. TECHNICAL MISHAP INVESTIGATION AND REPORT

If determined by the PCO, a technical mishap investigation may be conducted by a panel chaired by Government personnel. Otherwise, the contractor will conduct the investigation at the PCO's request. In either case, a document will be produced that provides details such as missile fragmentation maps, photographs, description of mishap, effects on adjacent operations, structural and equipment damage, Q/D drawings, detailed description of occurrence, findings, and conclusions. The technical mishap investigation report shall be

forwarded to the PCO through the ACO within 60 days of the official establishment of the investigative panel or, in the case of the contractor's investigation, from the date of the accident. The contractor will be informed immediately upon determination that the Government will form a panel to go on-site for accident investigative purposes.

CHAPTER 3

SAFE PRACTICE STANDARDS

A. GENERAL

This chapter provides general safe practice standards applicable to all A&E operations addressed in this Manual. When these standards exceed or differ from local or national codes or standards, the more restrictive shall apply.

B. PERSONNEL AND MATERIALS LIMITS

1. The cardinal rule to be observed in any location or operation involving explosives, ammunition, severe fire hazards, or toxic materials is to limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of the hazardous material consistent with safe and efficient operations. All operations shall be examined to devise methods for reducing the number of people exposed, the time of exposure, and the quantity of material subject to a single incident. Determination of personnel limits requires that jobs not essential to a particular hazardous operation be performed elsewhere; that no unnecessary personnel visit the location; and that frequent, consecutive operations will not be permitted in the same room or building without adequate dividing walls, firewalls, or operational shields, depending upon the nature of the hazard. Personnel limits should allow for necessary supervision and transient workers.

2. Determination of limits for hazardous materials requires a careful analysis of all facts including operation timing, intraplant transportation methods, size of the items, and the chemical and physical characteristics of the material. Stricter limits are required for the more sensitive or hazardous materials. Limits should be established for each operation rather than on an overall basis, so that each worker may be charged with the responsibility of not exceeding the established limit. Limits need not be expressed in units of weight or in the number of items as such. They may be given in terms of trays, boxes, racks, or other units more easily observed and controlled. Explosives limits shall not be established on the basis of the maximum quantity of explosives allowable as defined by the existing quantity/distance separation to nearby exposures when lesser quantities of explosives will suffice for the operations.

3. The maximum personnel and explosives limits permitted at any one time shall be prominently displayed in all buildings, cubicles, cells, and rooms containing A&E. These limits must be kept current, and enforced by the supervisor, foreman, or worker in charge. The personnel and explosives limits for all operations shall be recorded in the applicable Standard Operating Procedure (SOP). Personnel limits need not be posted in storage magazines, magazine areas, or transfer points. Explosives limits need only be posted in storage magazines for which the limit differs from that for other magazines in the block, or when unusual circumstances prevent the limit from being readily apparent.

C. STANDING OPERATING PROCEDURES (SOPs)

The basic requirement is for all operations involving hazardous materials to be developed in advance, and expressed in such a way as to avoid confusion and ensure process control at all times. An adequate SOP shall be developed and reviewed by qualified personnel before starting any operation involving A&E before starting any operation involving A&E.

1. Preparation. All aspects of a procedure shall be examined to determine a safe and orderly course of action for accomplishing the work. Controlled tests may be necessary in order to establish SOPs for certain operations. The SOP shall include, at a minimum, such items as safety requirements; specific emergency procedures; personal protective clothing and equipment; personnel and explosives limits for each operation; equipment designation; location and sequence of operations; and the particulars regarding how, when, where, and by whom each task of the operation shall be performed.

2. Dissemination. Supervisors shall be responsible for explaining duties prescribed by the SOP to all personnel involved in an A&E operation.

3. Posting. Applicable portions of the approved SOP, determined by the managing authority to be necessary to facilitate operations, shall be posted in a spot convenient to all stations involved in the operation. This need not be at the work station if the worker could be distracted, causing an accident. Supervisory personnel should maintain copies of the entire SOP, they must assume responsibility for enforcing its provisions.

4. Emergency Procedures. Action to be taken in the event of electrical storms, utilities, or mechanical failures and the like, occurring during the manufacturing, handling, or processing of A&E and other hazardous materials, shall be set forth in the SOP as described in the preceding paragraphs, or shall be set forth in separate SOPs prepared specifically for such purposes.

5. Recertification. SOPs should be constantly reviewed by qualified personnel, and changed and recertified by the managing authority as often as necessary to reflect improved methods, equipment substitutions, facility modification, or process revisions.

6. Training. Operator training should cover approved safety procedures, hazardous materials information, safety and warning devices, personal protective clothing and equipment, and emergency equipment.

D. STORAGE IN OPERATING BUILDINGS

1. Only those quantities of hazardous materials (excluding explosives and pyrotechnic materials) essential for current operations shall be stored within an operating building. Explosive materials exceeding work requirements shall be stored in a separate service storage magazine area located at the appropriate intraline distance from the operating building or area, based on the quantity of explosives stored in the service magazine.

2. If the intraline distance required by operational necessity is not available, contractors may designate in-process holding containers, structures within the operating building, provided the following apply:

a. Those containers/structures would preclude propagation from the operational location to the holding site if an explosives mishap should occur at the operational site.

b. Consideration is given to the structural containment afforded, venting, and the use of nonpropagating packaging within the temporary holding site.

c. Quantities of A&E in these holding sites are kept as low as possible, not exceeding amounts required for a 4-hour supply.

d. Procedures have been developed to minimize exposure during transfer operations.

e. Plant managers acquire and approve documented test results that confirm nonpropagation characteristics.

3. If operationally required, A&E that are a part of the work in process within the building may be stored in operating buildings during non-operational hours, providing the following requirements are strictly observed:

a. Explosives limits are not exceeded.

b. Containers of bulk explosives or propellants are secured and covered.

c. Processing equipment, such as powder hoppers and pipelines, is empty.

4. Before an operation in a building shuts down for longer than a weekend or normal holiday period, all hazardous materials should be processed through the facility. If this is not possible, as much of the in-process material as possible should be processed and transferred to an approved storage area before shutdown; no raw material should be introduced. The additional precautions listed in paragraph D.3., above, shall apply, and responsible personnel shall be informed of the above storage conditions.

E. HOUSEKEEPING IN HAZARDOUS AREAS

1. Structures containing explosives shall be kept clean and orderly.

2. In explosives areas, waste material such as oily rags, combustible and explosive scrap, and paper, shall be kept separate from each other. Such waste should be placed in marked, covered containers, preferably located outside the buildings. Containers for scrap black powder, scrap initiating explosives, scrap explosives of similar sensitivity, and rags contaminated with these explosives must be provided with covers and contain enough water or No. 10 mineral oil or fuel oil for certain pyrotechnic, tracer, flare, and similar mixtures to cover the scrap or rags. To minimize the hazards from gases formed when water is used in containers for scrap pyrotechnic, tracer, flare, and similiar mixtures, scrap should be immediately immersed. Combustible or explosive scrap should not be left in unoccupied buildings.

3. Explosives and explosives dusts must not accumulate on structural members, radiators, heating coils, steam, gas, air, water supply pipes, or electrical fixtures.

4. Spillage of explosives and other hazardous materials shall be prevented by proper design of equipment, training of employees, provision for catch pans, etc. For example, hoppers should be large enough to comfortably accommodate the size of charges used. A painted stripe on the inside of the hopper will serve as a reminder of the proper filling height. Catch pans or splash pans should be provided beneath drawoff pipes and TNT flakers, around transfer piping, beneath powder bags on small arms ammunition charging machines, etc. Spillage must be promptly removed.

5. A regular program of cleaning should be conducted to maintain safe conditions. General cleaning shall not be conducted while hazardous operations are being performed.

6. Hot water or steam should be used for cleaning floors in buildings containing explosives. When neither is practical, sweeping compounds that are nonabrasive and compatible with the explosives involved may be used. Such compounds may be combustible, but not volatile (closed cup flash point must not be less than 230°F). Sweeping compounds containing wax will not be used on conductive flooring. Because nitrated organic explosives can form sensitive explosive compounds with caustic alkalies, cleaning agents containing such alkalies must not be used around them.

7. Nonferrous wire brushes may be used in cleaning explosives-processing equipment only when other methods of cleaning are ineffective; a thorough inspection should follow such cleaning to ensure that no wire bristles remain in the equipment. This applies also to cleaning magnesium ingot molds and molds for any other metal used in an explosive. Substituting fiber brushes for hair brushes is recommended to reduce generation of static.

8. All loose explosives swept up from floors of operating buildings shall be destroyed. Explosives recovered from sources other than ammunition breakdown operations and equipment shall be thoroughly inspected, then reused, screened, reprocessed, or destroyed, as the situation warrants.

F. PROCEDURE BEFORE ELECTRICAL STORMS

1. When an electrical storm approaches, personnel shall be evacuated from locations where lighting could initiate explosives. Such locations include:

a. Operating buildings or facilities containing explosives or explosives-loaded ammunition, not equipped with lightning protection systems; and locations within unbarricaded intraline distance of such facilities.

b. Buildings containing explosives dust or vapors, whether or not equipped with lightning protection systems; and locations within unbarricaded intraline distance of such buildings.

c. Magazines, open storage sites, or loading docks, not equipped with lightning protection systems.

d. Locations, with or without lightning protection, where operations involving electro-explosive devices are being performed.

2. A qualified person, in authority should make the final decision about evacuation. When special warning is required for shutdown, volunteer observers or a detector (lightning detection system) may be used.

3. Personnel shall be evacuated from an operating line and proceed to suitable protective shelters located at intraline distance from operating buildings or other hazardous locations. When protective shelters are not available, personnel shall be withdrawn to inhabited building distances from the hazardous location.

G. EXPLOSIVES IN PROCESS DURING SHUTDOWN

When electrical storms cause evacuation of buildings with explosives, operations requiring constant attention shall continue to be manned by the minimum number of personnel consistent with safety requirements. Once the process has reached a condition in which it is considered safe to leave, the building shall be completely evacuated. No explosives process requiring constant attention should be started when an electrical storm threatens. Because of the possibility of power failure, alternate emergency power equipment lacking the capability to start automatically should be manned at such times.

H. MAINTENANCE AND REPAIRS TO EQUIPMENT AND BUILDINGS

1. All new or newly repaired processing equipment must be examined and tested to ensure that it is in safe working condition before being placed into routine use in hazardous operations.

2. Before repairs can proceed on equipment exposed to explosives, a tag certifying that no explosives remain, signed by supervisory personnel, shall be placed on the equipment. The tag shall identify parts that could not be cleaned, and shall provide maintenance personnel with instructions on safe handling.

3. Major repairs or changes will not be undertaken in a building during regular operations until the hazardous material has been removed and the employee in charge of the building informed.

4. Repairs cannot start in an explosives location until all explosives and dust found during an inspection of the immediate vicinity have been removed from equipment, crevices, areas beneath floors, within walls and pipes, and under fittings where explosives could be ignited. The entire area should be wetted or washed down thoroughly.

5. After oiling, fixing, or adjusting machines and equipment, the tools used for the repairs shall be removed. Before work resumes, operators should check their own equipment to ensure its safe operating condition.

6 Electricians shall not wear conductive shoes while working on live electrical equipment. Exposed explosives and other static-sensitive hazardous material must be removed before electrical work begins.

7. Safe practices specified elsewhere in this Manual shall also apply to maintenance employees.

8. Maintenance and tool rooms in an operating line should be separated from explosives by intraline distance. Protection equivalent to that afforded by a suitable barrier shall be provided when this proves impractical.

I. SAFETY HANDTOOLS

1. Handtools constructed of wood or materials such as bronze, lead, beryllium alloys, and "K" Monel metal shall be used for work in locations that contain exposed explosives or hazardous concentrations of flammable dusts, gases, or vapors. The nonferrous metals used in so-called nonsparking tools can produce sparks.

2. If their strength makes the use of ferrous metal handtools necessary, exposed explosives and other highly combustible materials shall be removed from the area as required in paragraphs H.2., 3., and 4., above.

J. OPERATIONAL SHIELDS

The design and testing of operational shields shall be in accord with MIL-STD 398 (reference (a)). Interlocking devices shall be installed on any equipment used for explosives processing (the doors of which function as operational shields). This prevents the operator from inadvertently opening such doors while working.

K. SPECIAL CLOTHING

1. A changing area should be established for employees who must remove their street clothes to wear special clothing (explosives plant clothing, anticontamination clothing, impervious clothing, etc.). To avoid exposing people not involved in A&E operations to unnecessary risks, special clothing worn during A&E operations shall not be worn or taken away from the premises. Special clothing should not be altered. Cotton undergarments, including socks, shall be worn whenever generating static electricity could create a hazard.

2. Explosives plant clothing, generally referred to as powder uniforms, must be fastened with nonmetallic fasteners and easily removable. Pockets should be of the lattice type. Pants and sleeves should be tapered and without cuffs, and pants should extend over the tops of shoes or boots. These garments should be flame resistant or made of flame retardant material. Each plant should have laundering facilities available for removing contaminants from explosives plant clothing. Regular testing will verify the effectiveness of the laundering operations.

L. CONDUCTIVE FOOTWEAR

1. Operators shall wear conductive shoes on conductive floors, mats, and runners. Personnel visiting any such area shall wear conductive shoes, ankle straps, or similar devices.

2. Tests of conductive shoes, or equivalent, shall be made initially and daily thereafter to ensure that the resistance from person to ground (through conductive flooring) is less than one million ohms. Documentation of this testing, to include calibration of test equipment, shall be kept by supervisory personnel. The test voltage must not exceed 500 volts. The short circuit current across the electrodes (plates) must not exceed 2.0 milliamperes (0.5 milliamperes is preferred). The instruments shall have built-in safeguards preventing the test subject from experiencing electric shock. Tests must not be performed in rooms with exposed explosives. Shoes should be tested first without cleaning the soles and heels; if the the resistance does not exceed allowed levels, the shoes may be worn. If resistance exceeds 450,000 ohms per shoe, the pair must be cleaned and re-tested. Sandpaper, solvents, or other agents affecting the structure or con-ductivity of the sole materials should not be used. Separating or removing the conductive sock liner from the conductive plug or depressing the conductive plugs below the surface of the insole of the shoe can cause high resistance. Nonconductive stockings such as silk, wool, and synthetics; and foot powders, which have a drying action, shall be avoided. Conductive shoes should be clearly labeled as such.

M. MATERIALS HANDLING EQUIPMENT

1. Gasoline-, diesel-, and LP-powered equipment will not be refueled inside warehouses or similar essential buildings containing ammunition and explosives. If the fuel supply is exhausted while the equipment is inside a building, the equipment shall be towed outside to a safe location for refueling: at least 20 feet from warehouses, other inert buildings, and inert loading docks; and 90 feet from explosives locations or buildings. Doors and windows through which vapors may enter the building shall be closed during refueling. Refueling trucks will not be located close to explosives buildings during refueling operations, but shall be parked as far as practicable from these buildings, in accordance with the above standards.

2. Gasoline-, diesel-, and LP-powered equipment will not be stored in buildings containing explosives or ammunition or on explosives loading docks or piers when A&E is present.

3. A central storage location for gasoline-, diesel-, and LP-powered equipment is preferred. Such a building should be located at least 50 feet from other buildings to avoid a fire hazard.

N. PARKING OF PRIVATELY OWNED VEHICLES

Controlled parking of privately owned vehicles within an establishment minimizes fire and explosion hazards and prevents congestion in an emergency. Vehicles should be parked in designated areas only, at intraline distance and outside of restricted areas. Vehicles shall not be parked so close to an explosives building or structure that fire could spread from them to the building, or that they could impede firefighters.

O. PROHIBITED ARTICLES IN HAZARDOUS AREAS

Except as authorized, personnel must not carry matches, cigarette lighters, or other flame-producing devices into explosive areas. Personal articles that increase existing hazards are also prohibited.

P. PHOTOGRAPHIC MATERIALS IN HAZARDOUS AREAS

Photoflash bulbs or electronic flash attachments shall not be used around exposed explosives, explosive dusts, flammable gases, or vapors. Only lighting equipment bearing the Underwriters Laboratories (UL) seal of approval for the hazard involved shall be used.

Q. OPERATIONAL EXPLOSIVES CONTAINERS

1. Explosives must be placed in containers that will prevent leakage. Containers used for intraplant transportation operations or service storage of explosives, such as initiating explosives, pyrotechnic compositions, and tracer materials, should be made of material in the following order of preference:

a. Conductive rubber.

b. Nonferrous metal-lined boxes without seams or rivet heads under which explosive dusts could accumulate.

c. Plastics (conductive type only).

d. Paper-lined wooden boxes.

e. Fiber drums.

2. These containers shall be the same size, shape, and color; marked with the type of explosives or hazard involved.

3. Because of their fragility and potential to fragment, glass containers should not be used.

R. INTRAPLANT RAIL TRANSPORTATION

This section addresses intraplant transportation safety standards and may exceed national standards because of material characteristics and operational hazards. When construction or major modification of transportation, packaging, or loading facilities is planned or anticipated, the contractor is responsible for ensuring that applicable Federal, State, and local standards and those contained within this Manual are met. The applicable standards promulgated by Department of Transportation (DOT) and other Federal or local regulatory agencies concerning preparation, marking, and shipment of ammunition and explosives should appear in the contract.

1. Operating Rules. Local procedures to ensure safe and efficient rail movement of A&E shall be developed, and shall include the following minimum requirements, as applicable:

a. Movements in the classification yards are considered switch movements. All others are considered transfer movements. Before cars containing A&E move, air hoses shall be coupled, air brakes cut-in and in proper working order, and the car doors closed. Cars should remain coupled while in motion. Safety precautions shall be observed when breaking air hose connections.

b. When single explosives-loaded cars are spotted, the hand brakes shall be set and the wheels properly chocked. When more than one car is spotted and its engine detached, the handbrakes shall be set on enough cars to ensure sufficient braking. Handbrakes shall be set on the downgrade end of the cut of cars. Reliance should not be placed on the automatic air brakes to hold spotted cars.

c. A person should be stationed at the handbrake of a car mover being used to move a car.

d. During transfer movements within establishments, full or partial loads in cars being moved by locomotives shall be blocked and braced so they cannot shift position.

e. Empty cars shall remain in warehouses, magazines, buildings, or loading docks until all warning placards have been removed or reversed, as appropriate.

f. Special care shall be taken to avoid rough handling of cars containing A&E. These cars will not be "sent off" while in motion and shall be carefully coupled to avoid unnecessary shocks. Other cars will not be "cut off" and allowed to strike a car containing explosives.

g. A bumper car should separate railcars containing explosives and the switching engine when in motion.

h. Flags or signals at both ends of a car or cut of cars shall protect personnel working in, on, or under the cars. During these periods, cars must not be coupled or moved.

i. Portable transmitters and railroad locomotives equipped with two-way radios will not transmit when passing explosives operating buildings where electro-explosive devices are in use. The contractor shall determine minimum safe distances based on Radio Frequency (RF), Frequency Modulation (FM), and Amplitude Modulation (AM) energies involved.

2. Railcar Inspections

a. Qualified personnel shall inspect empty railcars intended to transport A&E upon arrival, verifying that the carrier has complied with DOT requirements.

b. Before loading, the brakes shall be set on cars spotted for loading, and bridge plates equipped with side boards and stops shall be provided.

3. Loaded Incoming Railcar Inspection

a. Railroad cars with A&E should, upon arrival, be inspected at remote sites complying with Q/D requirements.

b. A&E-loaded cars on which foreign and suspicious articles have been attached outside or underneath the car, or that have a defect which could affect the safety of the installation or the contents of the car, shall be removed to the suspect car site for additional inspection.

c. After passing the exterior inspection, cars may be opened for interior inspection at the remote site (paragraph 3.a., above) or at the designated unloading point.

d. Cars should be inspected after unloading A&E to ensure that they are clean and free from loose explosives and flammable materials, and that placards and car certificates have been removed. Explosives sweepings shall be properly discarded.

S. INTRAPLANT MOTOR VEHICLE TRANSPORTATION

1. Vehicle Inspection. All motor vehicles used to transport A&E shall be inspected before loading.

a. Batteries and wiring shall not come into contact with containers of A&E.

b. When portable lights or flares are required (mandatory in some states on public highways), they shall be of the approved magazine type or of the type designated "permissible" by the United States Bureau of Mines.

c. Exposed ferrous metal in the interior of the vehicle body shall be covered with nonsparking material when scrap and bulk explosives are being transported in containers that could be damaged, or when explosives could otherwise become exposed.

d. A portable fire extinguisher of the appropriate class shall equip any vehicle transporting A&E.

e. Motor vehicles transporting A&E within the establishment but outside the explosives area, shall bear at least two appropriate placards. These placards should be removed or covered whenever the vehicle is not loaded. Reflectorized placards are preferred.

f. Motor vehicles or equipment with internal combustion engines, used near explosives scrap, waste, or items contaminated with explosives, shall have exhaust system spark arrestors and carburetor flame arrestors (authorized air cleaners). They should be inspected and be cleaned when excessive carbon particles have accumulated

2. Operating Rules. Procedures for safely and efficiently moving A&E in motor vehicles shall be developed locally, and should include the following:

a. Brakes shall be set and the wheels chocked while loading and unloading on a grade.

b. A&E should not be loaded or unloaded when a motor vehicle's engine is running, unless the engine is providing power to accessories used in the loading and unloading, such as mechanical handling equipment.

CHAPTER 4

PRINCIPLES AND APPLICATION OF Q/D, STANDARD EXPLOSIVES FACILITIES, AND SITING REQUIREMENTS

A. GENERAL

This chapter sets forth the following:

1. Rules for establishing quantities of explosives.

2. Computations and determinations of quantity/distance.

3. Assessment of the explosion effects, such as facility damage and personnel injury expected at specific scaled distances for class 1, division 1, explosives.

4. Recommended methods for controlling the effects of class 1, division 1, explosiors.

5. Acceptable exposures at specific scaled distances.

6. Types and general specifications of various ammunition and explosives facilities.

7. Siting requirements for specific facilities.

B. ESTABLISHMENT OF QUANTITY OF EXPLOSIVES AND DISTANCES

1. Quantity of Explosives. The total quantity of explosives in a magazine, operating building, or other explosives facility shall be the net weight of the explosives, calculated upon the following bases. Such calculations are intended for use with the tables in this Manual.

a. Mass-detonating explosives: The NEW (net explosive weight).

b. Nonmass-detonating explosives:

(1) Propellants: The net propellant weight.

(2) Pyrotechnic Items: The sum of the net weights of the pyrotechnic composition and the explosives involved.

(3) Bulk metal powders and pyrotechnic composition: The sum of the net weights of metal powders and pyrotechnic composition in containers.

(4) Other ammunition: The net weight of high explosives plus any contribution determined by test, if any, from propellant, pyrotechnic components, or expelling charges.

c. Combinations of mass-detonating and nonmass-detonating A&E (excluding class 1, division 4): The total net weight of the mass-detonating and the nonmass-detonating A&E. If the nonmass-detonating items, alone, require a greater distance than the total explosives so computed, then this greater distance is mandatory.

d. Combinations of nonmass-detonating ammunition and explosives of different class 1 divisions shall be treated as follows:

(1) Determine the required separation for each division.

(2) Use the greatest separation of those determined.

2. Q/D Computations and Determinations

a. Throughout these standards, NEW is used to calculate distance by means of formula $D = KW^{1/3}$, where D is the distance in feet, K is a factor depending upon the risk assumed or permitted, and W is the NEW in pounds. Distance requirements are sometimes expressed by the value of K, such as K9, K11, and K18 to signify K = 9, K = 11, K = 18, respectively.

b. The quantity of explosives in a magazine, operating building, or other explosives site shall be considered the net weight of the controlling class of explosives contained therein (the class requiring the greatest separation).

(1) Blast waves will coalesce when two or more stacks of mass-detonating explosives detonate within short time intervals (that is, when the time in milliseconds is less than 3.2 times the cube root of the explosive weight in pounds for lateral target positions and less than 4.5 times the cube root of the explosive weight in pounds for axial target positions). The resultant shock wave will be that of a single detonation of a charge equal to the sum of the several stacks. The actual separation time between successive detonations is influenced by the spatial separation, geometry, and distribution of explosives; the character of the dividing wall or other barrier; and the sensitivity of the explosives.

(2) When Q/D computations indicate advantages to dividing a quantity of mass-detonating explosives into smaller stacks, a suitable barrier or adequate separation distance must prevent propagation from one stack to another. Barriers designed and constructed in accordance with TM 5-1300, AFM 88-22, NAVFAC P-397 (reference (d)) satisfy this requirement. In such cases, the explosives content of the stack requiring the greatest distance will govern. Otherwise Q/D computations must be based on the sum of the mass-detonating explosives in all of the stacks.

c. The quantity of explosives permitted in each of two or more locations shall be determined by considering each location as a potential explosion site (PES). The quantity of explosives permitted in each of these locations shall be the amount permitted by the distance specified in the appropriate Q/D tables considering each as a potential target site in turn, except for service magazines (see paragraphs C.1.g. and C.2.g., below).

d. Quantity/distance tables are in Chapter 6.

e. Interpolation between distances specified in Q/D tables for class 1, divisions 1 and 3, shall be made as follows:

(1) Division 1. Using the formulas specified in the division 1 tables (tables 6-1, 6-3, and 6-4).

(2) Division 3. In accordance with the notes to table 6-10.

f. It is impractical to specify Q/D separations large enough to allow for the designed flight range of propulsive units (rockets, missile motors, and catapults) that properly belong in class 1, division 1, 2, or 3. Therefore, maximum flight ranges for units in a propulsive state will be disregarded. The distance required to protect from fragments in credible accident situations, however, will be established in accordance with the principles in Chapter 6, paragraph B.6., below.

g. Distances used to calculate the quantity of explosives allowed shall be measured from the nearest part of an exposed structure or site, to the nearest wall of the controlling subdivision or the entire structure containing explosives, as appropriate. Separation distances are measured along straight lines.

h. Where railroad cars or motor vehicles containing ammunition and explosives are not separated from operating buildings, magazines, or open A&E storage sites in a manner precluding their mass detonation, the separation distance will be based on the total quantity of explosives (see paragraph B.1., above) and measured from the outside wall of the building, railcar, vehicle, or edge of open stack closest to the target. If the explosives are separated into smaller units so that mass-detonation of the explosives in the railcars and motor vehicles and inside unit or units will not occur, the separation distance shall be measured from the controlling explosives unit, railcar, or vehicle closest to a target.

3. Class 1, Division 1, Explosion Effects, Exposure Controls, and Degree of Safety Afforded. Facility damage and personnel injury from class 1, division 1, A&E, principally depend on blast overpressure and impulse, although for limited quantities fragment hazards may control Q/D. For general purposes, peak incident overpressure is the blast parameter defining maximum permissible levels of exposure. However, in specific instances the physical characteristics of exposed structures (such as mass, stiffness, ductility, etc.) can make blast impulse the principal damage-causing factor.

a. Separation distances for standard igloo magazines (tables 6-4 and 6-5) provide virtually complete protection against propagation of explosions among igloo magazines by blast, fragments, or fire. Some cracking of concrete barrels and rear walls, spalling and severe cracking of front walls, and damage to doors and ventilators may, however, occur.

b. Aboveground magazine distances (see table 6-4, columns 11 and 12), provide considerable protection against propagation of explosions among aboveground magazines by blast. Depending on ammunition type, however, there is a risk of delayed propagation by fragments or of fire spreading from one magazine to another. Properly designed and placed barricades reduce the risk of communicating explosion through high-velocity, low-angle fragments. Without barricades, this risk is high.

(1) The aboveground magazine separation distance of $6W^{1/3}$ feet corresponds to a peak overpressure level of 27 psi (1.8 bars) (1 bar = 14.5 psi) when the explosion source is in the open. Neither the overpressure nor any other pertinent blast parameter, such as impulse, will be significantly reduced by an ordinary storage building of conventional unstrengthened

industrial construction at the explosion site, or by the barricade required between aboveground magazines at this distance. A conventional unstrengthened building exposed at this distance will be destroyed, vehicles overturned and crushed, and all occupants killed.

(2) The unbarricaded aboveground magazine separation distance of $11W^{1/3}$ feet corresponds to a peak overpressure level of 8 psi (0.5 bars) from an explosion source in the open. Blast observed at this distance will be suppressed only slightly by a storage building of conventional construction at the explosion site. A conventional unstrengthened building exposed at this distance will be destroyed. Blast will seriously injure eardrums and lungs of any survivor, as will being blown down or struck by fragments or building debris. Vehicles will be severely damaged by blast and may be inoperable.

c. At blast overpressure of 12 psi (0.7 bars) occurring at scaled distance of $9W^{1/3}$ feet (see table 6-3, column 3):

(1) Unstrengthened buildings will suffer severe structural damage approaching total destruction.

(2) People at the exposed site will be killed or severely injured by being thrown about by blast or by building collapse.

(3) Aircraft will be damaged beyond repair. If the aircraft are loaded with explosives, delayed explosions are likely to result from subsequent fires.

(4) Transport vehicles will be heavily damaged, probably to the extent of total loss.

(5) Direct propagation of explosion between two explosives locations is unlikely when barricades between them intercept high-velocity, low-angle fragments (see paragraph D.1., below).

(6) Improperly designed barricades or structures increase the hazard from flying debris; further, their probable collapse threatens personnel and equipment.

(7) Exposed structures housing personnel or containing equipment that is monetarily valuable or critically important to the mission, may require hardening.

d. At blast overpressure of 3.5 psi (0.24 bars) occurring at scaled distance of $18W^{1/3}$ (see table 6-3, column 4):

(1) Direct propagation of explosion is not expected.

(2) Delayed communication of explosion from fires, or equipment failure at the exposed site (ES), is possible.

(3) Unstrengthened buildings will sustain serious damage, approximating 50 percent of the total replacement cost.

(4) Personnel will be critically injured or killed by fragments, debris, firebrands, etc.

(5) There is a 10 percent chance of eardrum damage to personnel.

(6) Aircraft will be severely damaged from blast, fragments, and debris.

(7) Transport vehicles' body panels will be dished and shatter-resistant window glass will crack. Though extensive, this damage will not prevent the vehicles from operating.

(8) Overpressure control by suppressive construction at the PES, or by protective construction at the ES, is recommended if it is more economical than distance alone, or if distance cannot suffice.

e. At blast overpressure of 2.3 psi (0.16 bars) occurring at scaled distance of $24W^{1/3}$ (for quantities up to 100,000 pounds, see table 6-1, column 8).

(1) Unstrengthened buildings will sustain damage approximating 20 percent of their replacement cost.

(2) Occupants of exposed structures may suffer temporary hearing loss or be injured by such blast effects as building debris and being bodily thrown about.

(3) Personnel in the open should not be seriously injured by the blast itself. Fragments and debris could, however, cause injuries, depending on the PES structure and the fragmentation characteristics and amount of ammunition within.

(4) Vehicles on the road should not be damaged unless hit by fragments or the operator loses control during the blast wave.

(5) Aircraft appendages and sheet metal skin could be damaged by blast and possibly fragment penetrations, but should be operational after minor repairs.

(6) Barricading at the PES reduces injury and damage from fragments from limited quantities of explosives. Suppressive construction at the PES or protective construction at the ES are practical ways of controlling blast overpressure.

f. At blast overpressure of between 2.3 psi (0.16 bars) and 1.7 psi (0.1 bars) effects and controls are intermediate between those described in paragraph B.3.e., above, and B.3.g., below (for quantities between 100,000 and 250,000 pounds, see table 6-1, column 8).

g. At blast overpressure of 1.7 psi (0.1 bars) occurring at scaled distance of $30W^{1/3}$ (for quantities over 250,000 pounds, see table 6-1, column 8):

(1) Unstrengthened buildings will sustain damage approximating 10 percent of their replacement cost.

(2) Occupants of exposed unstrengthened structures may suffer injury from secondary effects, such as building debris.

(3) Aircraft landing and taking off could lose control and crash.

(4) Parked military and commercial aircraft, with minor damage due to blast, should remain airworthy.

(5) Personnel in the open should not be seriously injured by the blast itself. Depending largely upon the PES structure and the fragmentation characteristics and amount of ammunition within, however, fragments and debris could cause injuries.

(6) Barricading at the PES or application of minimum fragment distance requirements may reduce injury or damage due to fragements from limited quantities of explosives.

h. At blast overpressure of 1.2 - 0.90 psi (0.08 - 0.06 bars) occurring at scaled distance of $40W^{1/3}$ - $50W^{1/3}$ (see table 6-1, column 3):

(1) Unstrengthened buildings will sustain damage approximating 5 percent of their replacement cost.

(2) Personnel injuries are principally caused by glass breakage and building debris.

(3) Personnel in the open should not be seriously injured by the blast itself. Depending largely upon the PES structure and the fragmentation characteristics and amount of ammunition within, however, fragments and debris could cause injuries.

(4) Both orientation and limiting the surface area of exposed glass panels can reduce breakage and structural damage.

C. PERMISSIBLE EXPOSURES TO BLAST OVERPRESSURE

1. At sites exposed to potential blast overpressure of 12 psi (0.7 bars) occurring at $9W^{1/3}$ (see table 6-3, column 3), barricade required unless otherwise indicated (see paragraph B.3.c.(7), above), the following facilities or operations are permitted:

a. Buildings housing successive steps of a single production, renovation, or maintenance operation.

b. Breakrooms and change houses, if part of an operating line and used exclusively by personnel employed in operations of the line.

c. Temporary holding areas for trucks or railcars containing explosives to service production or maintenance facilities.

d. Field operations in magazine areas, when performing minor maintenance, preservation, packaging, or surveillance inspection.

e. Unmanned auxiliary power facilities, transformer stations, water treatment and pollution abatement facilities, and other utility installations that serve the PES but are not integral, the loss of which would not create an immediate secondary hazard. These do not need barricades. However, unmanned auxiliary power generating or converting facilities supplying power exclusively to the explosives storage area and security fence lighting may be located as close as fire distance from explosives facilities (80 feet for fire-resistant structures and 100 feet for nonfire-resistant structures).

f. Dunnage preparation and similar support structures housing non-explosives operations, if used only by PES employees.

g. Service magazines that are a part of operating lines. Distances are based on the quantity/type of ammunition or explosives in the service magazine(s), not in the operating building.

h. Exposures as indicated in subsection C.2., below, if blast suppression, structure hardening, etc., provides comparable protection for the personnel and equipment involved.

2. At sites exposed to potential blast overpressure of 3.5 psi (0.24 bars) occurring at $18W^{1/3}$ (see table 6-3, column 4), the following facilities or operations are permitted:

a. Construction workers in the vicinity of ammunition production areas, waterfront areas where ammunition is being handled, or areas for loading explosives onto aircraft.

b. Surveillance, maintenance, and inspection buildings; and labor-intensive operations closely related to PES.

c. Comfort, safety, and convenience buildings exclusively supporting PES, including lunchrooms, motor pools, area offices, auxiliary fire stations, transportation dispatch points, and shipping and receiving buildings (not magazine area loading docks).

d. Operations and training functions manned or attended only by personnel operating the PES.

e. Parking lots for privately owned vehicles belonging to personnel at the PES.

f. Service magazines that are part of operating lines. Distances are based on quantity/type of ammunition or explosives in the service magazine(s), not in the operating building.

3. At sites exposed to potential blast overpressure of 2.3 psi (0.16 bars) occurring at $24W^{1/3}$ (see table 6-1, column 8), the following facilities or operations are permitted:

a. Public traffic routes for NEW under 100,000 pounds.

b. Personnel exposed to remotely controlled operations. NOTE: Personnel at control stations less than $24W^{1/3}$ from the PES, though provided with blast-attenuating and fragment-defeating shields, must not be exposed to overpressure greater than 2.3 psi (0.16 bars).

c. Open-air recreation facilities exposed to PES containing NEW of up to 100,000 pounds, such as baseball diamonds, volleyball courts, etc., used by personnel assigned to the facility, where structures are not involved.

4. At sites exposed to potential blast overpressure of 1.7 psi (0.1 bars) occurring at $30W^{1/3}$ (see table 6-1, column 4), the following facilities or operations are permitted:

a. Public traffic routes.

b. Private vehicle parking in administrative areas. Minimum fragment distance should be applied.

5. At sites exposed to potential blast overpressure of 1.2 - 0.90 psi (0.08 - 0.06 bars) occurring at $40W^{1/3}$ to $50W^{1/3}$ (see table 6-1, column 3), the following facilities or operations are permitted:

a. Inhabited buildings; administrative and housing areas.

b. Plant boundaries.

c. Athletic fields and other recreation areas when structures are present.

d. Flight line passenger service facilities.

e. Utilities providing power to most of an establishment.

f. Storehouses and shops having strategically or intrinsically valuable contents which must not be jeopardized.

g. Functions which, if momentarily out of action, would cause an immediate secondary hazard.

D. AMMUNITION AND EXPLOSIVES FACILITIES

The following paragraphs indicate the types, general specifications, and siting requirements of various magazines for ammunition, explosives, and other dangerous materials.

1. Barricades and Earth Cover for Magazines

a. General. Both constructed barricades and undisturbed earth can protect ammunition and explosives, structures, and operations against high-velocity, low-angle fragments, although the barricades may be destroyed in the process. Further, barricades provide limited protection against blast in their immediate vicinity, provide no protection against high-angle fragments, and are ineffective in reducing the blast pressure in the far field (inhabited building or public traffic route distance).

b. Barricade requirements. Protection is considered effective when barricades meet the following minimum requirements:

(1) The slope of a barricade will not be steeper than 2/3 (rise/run). To reduce erosion and facilitate maintenance operations, future constructions should have a slope of 1/2.

(2) The earth barricade shall consist of material described in paragraph D.1.d., below.

(3) Barricade height and length shall be determined as follows:

(a) Height. Establish a reference point at the top of the far edge of one of the two stacks that the barricade is to separate. If the tops of the stacks are at different elevations, this reference point shall be on the lower stack. Draw a line from the reference point to the top of the other stack. Draw a second line from the reference point to form a 2 degree angle above the first line. To limit barricade height, each should be as close as possible to the stack that served as the reference point. (See figures 4-1 and 4-2.)

(b) Length. The length of the barricade will be determined as shown in figure 4-3.

(4) Earth barricades meeting the above requirements may be modified by substituting a retaining wall, preferably of concrete, for the slope on one side. The other side shall have slope and thickness sufficient to ensure that the width of earth required for the top is held firmly in place.

(5) Other barriers, such as earth-filled steel bin barricades for explosives-loaded aircraft, may also be used.

c. Location of Barricades. The distance between the foot of the barricade and the stack of ammunition or explosives or the buildings containing explosives represents a compromise. The shorter the distance, the shorter the height and length required for the barricade. However, it may be necessary to extend the distance to provide access for maintenance and vehicles. If it is impracticable to locate the barricades near the stack of ammunition or explosives or building containing explosives, barricades may be located adjacent to the facility to be protected.

d. Earth Cover for Magazines and Barricades

(1) Earth cover material for magazines and barricades shall be relatively cohesive (solid or wet clay and similar types of soil are too cohesive and should not be used), free from unsanitary organic matter, trash, debris, and stones heavier than 10 pounds or larger than 6 inches in diameter. The larger stones should be limited to the lower center of fill and never used for earth cover over magazines. Compaction and surface preparation shall be provided, as necessary, to maintain structural integrity and avoid erosion. Where cohesive material cannot be used, as in sandy soil, the barricade or the earth cover over magazines should be finished with a suitable material to ensure structural integrity.

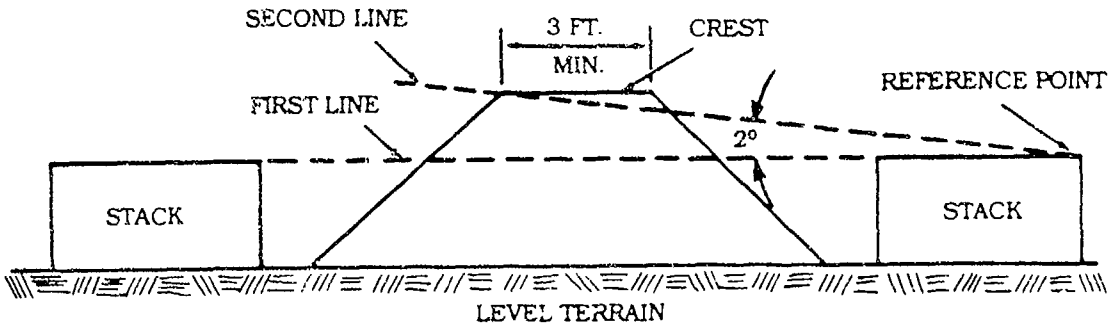

Figure 4-1. Determination of Barricade Height (Level Terrain).

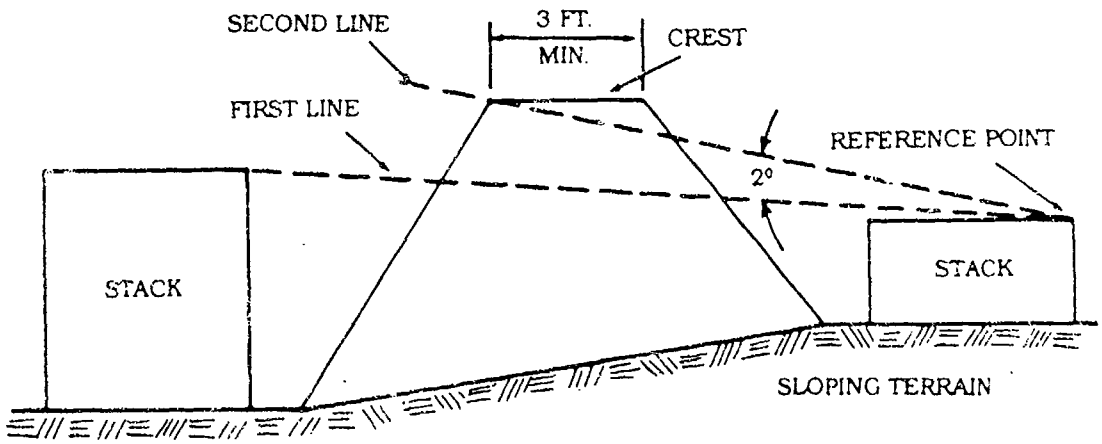

Figure 4-2. Determination of Barricade Height (Sloping Terrain).

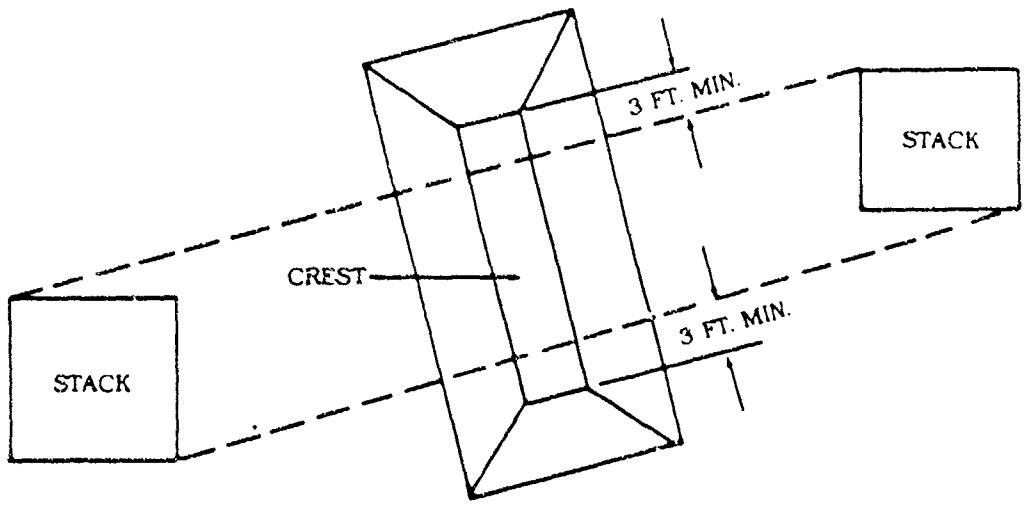

Figure 4-3. Determination of Barricade Length.

(2) The earthfill or earth cover between igloo magazines may be either solid or sloped, in accordance with the requirements of other construction features, but a minimum of 2 feet of earth cover must be maintained over the top of each magazine and a minimum slope of 2/3 (rise/run) starting directly above the spring line of each arch must be maintained. To reduce erosion and facilitate maintenance operations, future constructions should have a slope of 2 horizontal to 1 vertical.

2. Application of Q/D to Igloo Magazines

a. For application of quantity/distances, magazines must not have been structurally weakened to the extent that they could not be expected to prevent propagation of explosives. The specified thickness and slope of the earth cover must be maintained.

b. Normally, igloo magazines will not be constructed to face door-to-door. They should face in the same direction with the long axes parallel to each other. In special cases where topographic or other important considerations would result in different orientations, they shall be sited in accordance with Chapter 6, paragraph D., below.

3. Policy on Protective Construction. The present "state of the art" in protective construction is such as to permit any calculated level of protection from explosion communication between adjacent bays or buildings, personnel protection against death or serious injury from incidents in adjacent bays or buildings, and protection of vital and expensive equipment installations. Therefore, the major objectives in facility planning should be:

a. Protection against explosion communication between adjacent bays or buildings and protection of personnel against death or serious injury from incidents in adjacent bays or buildings (see paragraphs B.2. and 3., above). In situations where the protection of personnel and facilities would be greatly enhanced or costs significantly reduced by having separate buildings to limit explosion propagation rather than using protective construction and separation of explosive units within one building, planning should reflect this fact.

b. Provision of protection for vital and expensive equipment, if the additional cost is warranted.

c. When an appropriate degree of protection can be provided either by hardening a target building or constructing a source building to suppress explosion effects, these factors may be taken into account and the distances required by the standard Q/D tables reduced. The rationale or test results justifying the reduction must accompany A&E site and general construction plans proposing reduced distances based on protective construction, when submitted for PCO approval.

E. SPECIFIC SITING STANDARDS

1. Rail and Truck Holding Yards

a. Generally, rail holding yards should be laid out on a unit car/group basis with each unit car/group separated by the applicable aboveground magazine distance.

b. If the rail holding yard is formed by two parallel ladder tracks connected by diagonal spurs, the parallel tracks and the diagonal spurs shall be separated by applicable aboveground magazine distances for the unit/group quantities of high explosives.

c. If the rail holding yard is a "Christmas tree" arrangement, consisting of a ladder track with diagonal dead-end spurs projecting from each side at alternate intervals, the spurs should be separated by the applicable aboveground magazine distance for the net quantity of high explosives in the cars on the spurs.

d. Generally, truck holding yards should be laid out on a unit truck/group basis with each group separated by the applicable aboveground magazine distances.

e. Both rail and truck holding yards shall be separated from other facilities by the applicable Q/D criteria.

2. Classification Yard

a. To protect the classification yard from external explosions, separation distances shall, at least, be the applicable magazine distance.

b. Specific quantity/distance separation is not required from the classification yard to targets other than explosive locations when the classification yard is used exclusively for the following:

(1) Receiving, dispatching, classifying, and switching of cars.

(2) Interchanging of trucks, trailers, railcars, or MILVANS between the common carrier and the establishment.

(3) Conducting external inspection of motor vehicles and railcars.

(4) Opening free rolling doors of railcars to remove documents and visually inspect cargo. If the yard is used for any other purpose, such as taking dunnage or explosive items into or out of cars, Q/D tables apply (see paragraphs B.2.a. through h., above.)

3. Railcar and Motor Vehicle Inspection Stations

a. Specific quantity/distance separations are not required for inspection stations; however, they should be as remote as practicable from hazardous or populated areas. The following activities may be performed at the inspection station after railcars or motor vehicles containing ammunition and explosives are received from the delivering carrier, before further routing within the installation:

(1) Visual inspection of railcar and motor vehicle exteriors.

(2) Visual inspection of the cargo in vehicles (trucks, trailers, railcars, MILVANS, etc.) that have passed the external inspection indicated above.

(3) Interchange of trucks, trailers, railcars, or MILVANS between the common carrier and the establishment.

b. If any activities other than the above are conducted at the inspection station, Q/D tables apply.

c. Any cars or trucks suspected of being hazardous will be isolated consistent with applicable Q/D separation for the hazard class and explosives quantity involved. This shall be accomplished before any subsequent action.

4. Administration and Industrial Areas

a. Administration and industrial areas shall be separated from explosives concentrations by inhabited building distances.

b. Auxiliary facilities such as joiner shops, heating plants, and field offices that are required to be at explosives operations, serving only one building or operation, shall be located and constructed to provide prudent fire protection.

5. Underground Tanks or Pipelines. These should be separated from buildings or stacks containing A&E of hazard class 1, divisions 2 through 4, by a minimum distance of 80 feet. The separation for hazard class 1, division 1, should correspond to the formula $D = 3W^{1/3}$ with a minimum distance of 80 feet, unless the donor building is designed to contain the effects of an explosion.

6. Recreational, Training, and Other Such Areas. Open areas between explosives storage and handling sites and between these sites and nonexplosives buildings and structures, should be carefully controlled, when used as employee recreation or training facilities. The severe fragment hazard will usually extend from the explosion site to approximately the public traffic route distances. Accordingly, exposed recreation and training facilities where employees are in the open shall be sited at not less than public traffic route distances and as close to inhabited building distances as practicable. When structures, including bleachers, are included as part of these facilities, they shall be sited at not less than inhabited building distances.

7. Demolition or Burning Areas. Sites for demolition and burning of explosives shall be separated from other facilities based on the hazards associated with the quantity and type of material to be destroyed.

8. Parallel Operating Lines. These shall be separated from one another by no less than unbarricaded intraline distance ($18W^{1/3}$) for the hazard class and explosive quantities involved, whether or not barricaded, and provided that ammunition and explosives involved in each operating line present similar hazards. The criticality of survivability of one or more of the operating lines may require that each line be given an inhabited building distance level of protection.

CHAPTER 5

STORAGE COMPATIBILITY SYSTEM

A. GENERAL

1. Ammunition and explosives shall be stored in accordance with standards contained in this chapter.

2. Q/D relationships for specific classes of A&E (see Chapter 6) are based on levels of risk considered acceptable for stipulated exposures. Items of A&E are assigned to these classes on the basis of DoD hazard classification procedures. Hazard classifications include:

a. Final. This classification applies to end items or resupply items stored and transported in the approved container and packaging.

b. Interim. This classification is assigned to permit limited shipment and storage during research, development, and testing phases before assignment of the final hazard classification.

3. Tables 5-1, 5-2, and 5-3 present hazard classification information for a limited number of items and materials.

B. STORAGE COMPATIBILITY GROUPING

1. All A&E are assigned to an appropriate storage compatibility group (SCG).

2. Storage Principles

a. The highest degree of safety in A&E storage could be assured if each item or division were stored separately. However, such ideal storage is not generally feasible. A proper balance of safety and other factors frequently requires mixing of several types of ammunition and explosives in storage.

b. A&E will not be stored with dissimilar materials or items that present hazards to the munitions. Examples are mixed storage of A&E with flammable or combustible materials, acids, or corrosives.

c. Different types of A&E may be mixed in storage, by item and division provided they are compatible. A&E are assigned to a SCG when they can be stored together without significantly increasing either the probability of an accident or, for a given quantity, the magnitude of the effects of such an accident.

d. A&E should be mixed in storage only when such mixing will facilitate safe operations and promote overall storage efficiency.

e. As used in these standards, the term "with its own means of initiation" indicates that the ammunition has its normal initiating device assembled to it and this device is considered to present a significant risk during storage. However, the term does not apply when the initiating device is packaged in a manner that eliminates the risk of detonating the ammunition if the initiating

device should accidentally function, or when fuzed end items are configured and packaged to prevent their inadvertent arming. The initiating device may even be assembled to the ammunition, provided its safety features preclude initiation or detonation of the explosives filler of the end item if the initiating device should accidentally function.

3. Compatible Ammunition and Explosives

a. Different kinds of A&E within one compatibility group are compatible and may be stored together.

b. Ammunition and explosives in substandard or damaged packaging, in a suspect condition, or with characteristics that increase the risk in storage are not compatible with other A&E and shall be stored separately.

4. Storage Compatibility Groups. A&E are assigned to one of eleven storage compatibility groups (A through H, J, L, and S).

a. Group A. Initiating explosives. Bulk initiating explosives that have the sensitivity to heat, friction, or percussion necessary for use as initiating elements in an explosive train. Examples are wet lead azide, wet lead styphnate, wet mercury fulminate, wet tetracene, and dry PETN.

b. Group B. Detonators and similar initiating devices not containing two or more independent safety features. Items containing initiating explosives that are designed to initiate or continue the functioning of an explosive train. Examples are detonators, blasting caps, small arms primers, and fuzes.

c. Group C. Bulk propellants, propelling charges, and devices containing propellant with or without their own means of ignition. Items that upon initiation will deflagrate, explode, or detonate. Examples are single-, double-, triple-base, and composite propellants; rocket motors (solid propellant); and ammunition with inert projectiles. Liquid propellants are not included.

d. Group D. Black powder, high explosives (HE), and ammunition containing HE without its own means of initiation and without propelling charge and fuzes with two or more safety features. A&E that can be expected to explode or detonate when any given item/component thereof is initiated (except for fuzes with two or more safety features). Examples are bulk TNT, composition B, wet RDX or PETN, bombs, and CBUs.

e. Group E. A&E containing HE without its own means of initiation and with propelling charge.[1] Examples are artillery ammunition, rockets, and guided missiles.

f. Group F. Ammunition containing HE with its own means of initiation[2] and with or without propelling charge. HE ammunition or devices (fuzed), with or without propelling charges. Examples are grenades, sounding devices, and similar items having an in-line explosive train in the initiator.

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[1] See paragraph B.2.e., above.
[2] Not meeting requirements of paragraph B.2.e., above.

g. Group G. Fireworks; illuminating, incendiary, smoke (including HC), or tear-producing munitions other than those munitions that are water-activated or contain white phosphorus or flammable liquid or gel.

h. Group H. Ammunition containing both explosives and white phosphorus or other pyrophoric material. Ammunition in this group contains fillers which are spontaneously flammable when exposed to the atmosphere.

i. Group J. Ammunition containing explosives and flammable liquids or gels, with or without explosives. Ammunition in this group contains flammable liquids or gels other than those that are spontaneously flammable when exposed to water or the atmosphere. Examples are liquid- or gel-filled incendiary ammunition; FAE devices; flammable, liquid-fueled missiles; and torpedoes.

j. Group L. Ammunition not included in other compatibility groups, having characteristics that do not permit storage with other types of ammunition or kinds of explosives. Examples are water-activated devices; prepackaged, hypergolic liquid-fueled rocket engines; TPA (thickened TEA); and damaged or suspect ammunition of any group. Types presenting similar hazards (that is, oxidizers with oxidizers, fuels with fuels, etc.) may be stored together but not mixed with other groups.

k. Group S. Ammunition presenting no significant hazard. All hazardous explosive effects are confined and self-contained within the item or package. An incident may destroy all items in a single pack but must not communicate to other packs. Examples are thermal batteries, explosive switches or valves, and other ammunition items packaged to meet this criterion.

5. Mixed Storage

a. Mixing of SCGs is permitted as indicated in figure 5-1.

b. Items from SCGs C, D, E, F, G, J, and S may be combined in storage, provided the net quantity of explosives in the items or in bulk does not exceed 1000 pounds per storage site. These items must be packaged in original shipping container or equivalent.

c. In addition to paragraph B.5.b., above, items assigned to hazard class 1.4, SCG C, G, or S, may be combined in storage without regard to explosives quantity limitations.

GROUPS	A	B	C	D	E	F	G	H	J	L	S
A	X	Z									X
B	Z	X									X
C			X	Z	Z		Z				X
D			Z	X	X						X
E			Z	X	X						X
F						X					X
G			Z				X				X
H								X			X
J									X		X
L											
S	Z	X	X	X	X	X	X	X	X		X

Figure 5-1. Storage Compatibility Mixing Chart.

NOTES

1. An "X" indicates that the intersecting groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per note 2., below.

2. A "Z" indicates that, when warranted by operational considerations or magazine nonavailability, and when safety is not sacrificed, the intersecting groups may be combined in storage. Operational considerations include conditions that waste resources such as money, manpower, and energy, or compromise security, readiness, or the ability to accomplish the installation mission. Storage personnel, after consultation with safety personnel, should determine when operational considerations exist that warrant "Z" storage compatibility mixing. Examples of acceptable combinations of class 1 follow:

a. Division 1, group C, bulk propellants with division 1, group D, bulk HE.

b. Division 1, group C, rocket motors with division 1, group D, bombs (HE) without their own means of initiation.

c. Group C rocket motors with group E complete rocket systems having the same rocket motor.

d. Division 3, group C, bulk propellants or bagged propelling charges with division 3, group G, pyrotechnics without their own means of initiation.

3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled round; that is, WP filler in group H, HE filler in group D, E, or F, as appropriate.

4. See paragraph B.5., above, for permissible mixed storage of quantities of 1000 pounds or less.

5. Ammunition designated "practice" or "target practice" by national stock number and nomenclature may be stored with the fully loaded ammunition it simulated (for example, 2.75 inch TP rockets with WP rockets).

6. Ammunition items without explosives containing substances more suited to another hazard class may be assigned to the same compatibility group as items containing explosives and the same substances, and be stored with them.

Table 5-1. Summary of Hazard Classification and Storage Compatibility Groupings.

Item	Storage Compatibility Group	Hazard Class/ Division
Aluminum powder (in original shipping container or equivalent)	L	1.4
Aluminum powder (not in original shipping container or equivalent)	L	1.4
Ammonium nitrate (in original shipping container or equivalent)	L	1.4
Ammonium nitrate (not in original shipping container or equivalent) exposed to fire hazards only or to detonation hazards at more than intraline distance	D	1.3
Ammonium nitrate (not in original shipping container or equivalent) exposed to detonation hazards at less than intraline distance	D	1.1
Ammonium perchlorate (particle size 15 microns or less)	D	1.1
Ammonium perchlorate (particle size over 15 microns) in original shipping container or equivalent	L	1.4
Ammonium perchlorate (particle size over 15 microns) not in original shipping container or equivalent, exposed to fire hazards only or exposed to detonation hazards at more than intraline distance	D	1.3
Ammonium perchlorate (particle size over 15 microns) not in original shipping container or equivalent, exposed to detonation hazards at less than intraline destance	D	1.1
Ammonium picrate (Explosive D)	D	1.1
Baratol	D	1.1

Table 5-1. Summary of Hazard Classification and Storage Compatibility Groupings. (continued)

Item	Storage Compatibility Group	Hazard Class/ Division
Benite	C	1.1
Black powder, bulk	D	1.1
Boron potassium nitrate	C	1.1
Cartridge cases, primed (w/o propellant)	B	1.4
Chlorates (not in original shipping container or equivalent)	L	1.3
Compositions A, A-2, A-3, and A-4	D	1.1
Compositions B and B-3	D	1.1
Compositions C, C-2, C-3, and C-4	D	1.1
Cyclonite (RDX), dry	A	1.1
Cyclonite (RDX), wet	D	1.1
Cyclotol	D	1.1
DNT (exposed to detonation hazard at less than intraline distance)	D	1.1
DNT (exposed to detonation hazard at more than intraline distance)	D	1.3
Dynamite	D	1.1
EC Powder	C	1.1
Ednatol	D	1.1
Explosive D	D	1.1
Fuel (solid), emergency power unit	C	1.1
HMX, dry	A	1.1
HMX, wet	D	1.1
Lead Azide, wet	A	1.1

Table 5-1. Summary of Hazard Classification and Storage Compatibility Groupings. (continued)

Item	Storage Compatibility Group	Hazard Class/ Division
Lead Stypnnate, wet	A	1.1
Magnesium Powder (in original shipping container or equivalent)	L	1.4
Magnesium Powder (not in original shipping container or equivalent)	L	1.3
Mercury Fulminate, wet	A	1.1
Nitrates (inorganic), except ammonium nitrate (in original shipping container or equivalent)	L	1.4
Nitrocellulose, wet, containing 8-30 percent water, that is, exposed to detonation hazards at less than intraline distances	D	1.1
Nitrocellulose, wet, containing 8-30 percent water, that is, exposed only to other class 1.3 fire hazard materials	D	1.3
Nitroguanidine	D	1.1
Nitrostarch	D	1.1
Octol	D	1.1
PBX	D	1.1
Pentolite	D	1.1
Perchlorates[1] (in original shipping container or equivalent)	D	1.4
Perchlorates[1] (not in original shipping container or equivalent)	D	1.3
Peroxides, solid (in original shipping container or equivalent)	L	1.4
Peroxides, solid (not in original shipping container or equivalent)	L	1.3

[1]Excluding ammonium perchlorate.

Table 5-1. Summary of Hazard Classification and Storage Compatibility Groupings. (continued)

Item	Storage Compatibility Group	Hazard Class/ Division
Peroxides, solid (in original shipping container or equivalent)	L	1.4
PETN, wet	D	1.1
PETN, dry	A	1.1
Picratol	D	1.1
Picric acid	D	1.1
Propellant, single base, multi-perforated, w/web thickness greater than 0.019 inch (excluding single base propellant containing 98 percent or more nitrocellulose (NC).	C	1.3
Propellant, single base, containing 98 percent or more NC	C	1.1
Propellant, single base, single perforated (rifle)	C	1.3[2]
Propellant, single base (FNH and NH compositions), single perforated, cannon, w/web thickness not greater than 0.033 of an inch	C	1.3[2]
Propellant, single base, low pressure, for pistols and shotguns, etc.	C	1.3[2]
Propellant, double base, containing not more than 20 percent nitroglycerin (NG), w/web thickness of 0.0075 of an inch or greater	C	1.3[2]
Propellant, double base (for artillery ammunition) containing over 20 percent NG	C	1.1
Propellant, double base, w/web thickness less than 0.0075 of an inch, regardless of NG content	C	1.1

[2]Class 1.3 applies when stored in metal-lined wood boxes; when stored in all-metal containers not designed for quick release of pressure, class 1.1 applies.

Table 5-1. Summary of Hazard Classification and Storage Compatibility Groupings. (continued)

Item	Storage Compatibility Group	Hazard Class/ Division
Propellant, multiperforated, cannon and rifle, w/web thickness not greater than 0.019 of an inch	C	1.3[2]
Propellant, double base and composite grains found to be nonmass-detonating in tests conducted in accordance with TB 700-2 (reference (e))	C	1.3
Propellant, double base and composite grains found to be mass-detonating in tests conducted in accordance with TB 700-2 (reference (e))	C	1.1
Propellant grains, polysulfide-perchlorate, containing not more than 74 percent oxidizer	C	1.3
Tetracene, wet	A	1.1
Tetranitrocarbazole (TNC)	D	1.1
Tetryl	D	1.1
Tetrytol	D	1.1
Torpex	D	1.1
Tritonal	D	1.1
TNT	D	1.1
Zirconium (types I and II, spec. FED 1665) (in original shipping container or equivalent)	L	1.4
Zirconium (types I and II, spec. FED 16665) (not in original shipping container or equivalent)	L	1.3

[2]Class 1.3 applies when stored in metal-lined wood boxes; when stored in all metal containers not designed for quick release of pressure, class 1.1 applies.

Table 5-2. Storage Compatibility Groups for Explosives.

GROUP A

Cyclonite (RDX), dry
HMX, dry
Lead azide, wet
Lead styphnate, wet
Mercury fulminate, wet
PETN, dry
Tetracene, wet

GROUP B

Cartridge cases, primed (w/o propellant)

GROUP C

Benite
Boron potassium nitrate
Charge, propelling, not assembled to projectiles
EC powder
Fuel (solid), emergency power unit
Propellant

GROUP D

Ammonium nitrate (except in original shipping container or equivalent)
Ammonium perchlorate (except when particle size is over 15 microns and in original shipping container or equivalent)
Ammonium picrate (Explosive D)
Baratol
Black powder, bulk
Compositions A, A-2, A-3, A-4, B, B-3, C, C-2, C-3, and C-4
Cyclonite (RDX)
Cyclotol
DNT
Dynamite
Ednatol
Explosive D
HMX, wet
Nitrocellulose
Nitroguanidine
Nitrostarch
Octol
PBX
Perchlorates, except ammonium perchlorate
Pentolite
PETN, wet
Picratol
Picric acid
Tetranitrocarbazole (TNC)
Tetryl
Tetrytol

Table 5-2. Summary of Hazard Classification
and Storage Compatibility Groupings. (continued)

Torpex
Tritonal
TNT

GROUP L

Aluminum powder
Ammonium nitrate (in original shipping container or equivalent)
Ammonium perchlorate (particle size over 15 microns) (in original shipping container or equivalent)
Chlorates
Magnesium powder
Nitrates (inorganic), except ammonium nitrate (in original shipping container or equivalent)
Perchlorates
Peroxides, solid
Zirconium (types I and II, spec. FED 1665)

Table 5-3. Q/D Classes for Explosives.

Class 1.1

Ammonium nitrate (not in original shipping container or equivalent) exposed to detonation hazards at less than intraline distances
Ammonium perchlorate (particle size 15 microns or less)
Ammonium perchlorate (particle size over 15 microns) not in original shipping container or equivalent, exposed to detonation hazards at less than intraline distance
Ammonium picrate (Explosive D)
Baratol
Benite
Black powder, bulk
Boron potassium nitrate
Compositions A, A-2, A-3, A-4, B, B-3, C, C-2, C-3, and C-4
Cyclonite (RDX)
Cyclotol
DNT, exposed to detonation hazard at less than intraline distance
Dynamite
EC powder
Ednatol
Explosive D
Fuel (solid), emergency power unit
HMX
Lead azide, wet
Lead styphnate, wet
Mercury fulminate, wet
Nitrocellulose, wet, containing 8-30 percent water, exposed to detonation hazards at less than intraline distances
Nitroguanidine
Nitrostarch
Octol
PBX
Pentolite
PETN
Picratol
Picric acid
Propellant, double base (for artillery ammunition) containing over 20 percent NG
Propellant, double base, w/web thickness less than 0.0075 of an inch, regardless of NG content
Propellant, double base and composite grains found to be mass detonating in tests conducted in accordance with TB 700-2 (reference (e))
Propellant, single base, containing 98 percent or more NC
RDX (cyclonite)
Tetracene, wet
Tetranitrocarbazole (TNC)
Tetryl
Tetrytol
Torpex
Tritonal
TNT

Table 5-3. Summary of Hazard Classification
and Storage Compatibility Groupings. (continued)

Class 1.3

Ammonium nitrate (not in original shipping container or equivalent) exposed to fire hazards only or to detonation hazards at more than intraline distance
Ammonium perchlorate (particle size over 15 microns) not in original shipping container or equivalent, exposed to fire hazards only or exposed to detonation hazards at more than intraline distance
Chlorates (not in original shipping container or equivalent)
DNT (exposed to detonation hazard at more than intraline distance)
Magnesium powder (not in original shipping container or equivalent)
Nitrocellulose, wet, containing 8-30 percent water that is exposed only to such fire hazard materials as other class 1.3 items
Perchlorates (not in original shipping container or equivalent), except ammonium perchlorate
Peroxides, solid (not in original shipping container or equivalent)
Propellant, double base and composite grains found to be nonmass-detonating in tests conducted in accordance with TB 700-2 (reference (e))
Propellant, double base, containing not more than 20 percent nitroglycerin, w/web thickness of 0.0075-inch or greater
Propellant grains, polysulfide-perchlorate, containing not more than 74 percent oxidizer
Propellant, multiperforated, cannon and rifle, w/web thickness not greater than 0.019 of an inch
Propellant, single base, low pressure, for pistols and shotguns, etc.
Propellant, single base, multiperforated, w/web thickness greater than 0.019 of an inch (excluding single base propellant containing 98 percent or more nitrocellulose (NC)
Propellant, single base, single perforated, rifle
Propellant, single base (FNH and NH compositions), single perforated, cannon, w/web thickness not greater than 0.035 of an inch
Zirconium (types I and II, spec. FED 1665) (not in original shipping container or equivalent)

Class 1.4

Aluminum powder
Ammonium nitrate (in original shipping container or equivalent)
Ammonium perchlorate (particle size over 15 microns) (in original shipping container or equivalent)
Cartridge cases, primed (w/o propellant)
Chlorates (in original shipping container or equivalent)
Magnesium powder (in original shipping container or equivalent)
Nitrates (inorganic), except ammonium nitrate (in original shipping container or equivalent)
Perchlorates (in original shipping container or equivalent), except ammonium perchlorate
Peroxides, solid (in original shipping container or equivalent)
Zironium (types I and II, spec. FED 1665) (in original shipping container or equivalent)

CHAPTER 6

HAZARD CLASSIFICATION AND Q/D CRITERIA

A. GENERAL

1. This chapter outlines Q/D requirements applicable to storage, processing, and handling of A&E. The maximum amount of explosives permitted at any location is determined by the prevailing distance from that location to other exposures and the applicable Q/D table in this chapter. Greater distances than those shown in the tables should be used when practicable.

2. When sufficient protection can be provided by hardening a target building or constructing a source building to suppress explosion effects, this may be taken into account, and the distance required by the standard Q/D tables may be reduced. The rationale or test results justifying the proposed distance reduction must accompany A&E site and general construction plans when submitted through the ACO for the PCO's approval. (See Chapter 1, paragraph F.)

B. HAZARD CLASSES AND CLASS DIVISIONS

1. The hazard classification system is based upon the system recommended for international use by the United Nations Organization (UNO), consisting of nine classes for dangerous goods with ammunition and explosives included in UNO's "Class 1, explosives."

2. The A&E hazard classes are further subdivided into "divisions" according to the associated hazards, including the potential for causing personnel casualties or property damage. The list of items for each division contains examples; it is not all-inclusive.

3. The separation of the A&E hazard classes into the several divisions does not necessarily mean that the different items in a division may be stored together. Also, some items may appear in more than one division, depending upon factors such as the degree of confinement or separation, type of packaging, storage configuration, or state of assembly.

4. The maximum amount of explosives permitted in any location is limited by the Q/D criteria. Explosives limits shall be established in amounts no greater than those consistent with safe and efficient operations.

5. Class 1 is divided into the following four divisions that indicate the type of hazards expected:

Hazard Class and Division Designators	Hazards
1.1	Mass detonating
1.2	Nonmass detonating Fragment producing
1.3	Mass fire
1.4	Moderate fire, no blast
1.5	Insensitive high explosives

6. A numerical figure (in parenthesis) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands. This number will be placed to the left of the division designators 1.1 through 1.3, such as (18)1.1, (08)1.2, and (06)1.3. A minimum distance as shown in applicable tables will be used for all items in division 1.2.

a. For divisions 1.1 and 1.3, a minimum distance number will be used where the ranges of hazardous fragments and firebrands EXCEED the distances specified for inhabited buildings in the applicable Q/D table.

b. Minimum fragment distance protects personnel in the open; firebrand minimum distance primarily protects facilities.

c. Examples where minimum fragment and firebrand distances for divisions 1.1 and 1.3 need not be applied follow:

(1) Recreation or training facilities, if these facilities are for the exclusive use of personnel assigned to the potential explosion site.

(2) Between potential explosion sites and relatively static inert storage areas.

(3) Between facilities in an operating line, between operating lines, and between operating lines and storage locations normally separated by inhabited building distances to protect workers and ensure against interruption of production.

d. For demolition explosives, thin-cased or low-fragmentation ammunition items, bulk high explosives, pyrotechnics, and in-process explosives of division 1.1, the minimum distance to exposures will be 670 feet for 100 pounds NEW or less. For all division 1.1 A&E in quantities of 101 to 30,000 pounds NEW, the minimum distance will be 1,250 feet, unless it can be shown that fragments and debris from structural elements of the facility or process equipment will not present a hazard beyond the distance specified in table 6-1, column 3. For items that have been evaluated adequately, different minimum distances, as in table 6-2, may be used. In the application of this paragraph, "thin-cased" will refer to items presenting no more hazard from high-velocity primary fragments than a single 500-pound MK 82 bomb. (Facilities sited at 1,235 or 1,245 feet in accordance with past standards will be considered to be in compliance with the 1,250 foot minimum requirement.)

e. For public traffic routes that are not possible sites for future targets, and for other exposures permitted at public traffic route distances from potential explosion sites, fragment and firebrand minimum distance for divisions 1.1 and 1.3 may be reduced to 60 percent of these requisite distances.

7. When determining inhabited building and public traffic route distances, use table 6-1 for class 1, division 1; table 6-2 for specified class 1, division 1, items; tables 6-6 through 6-9 for class 1, division 2; table 6-10 for class 1, division 3; and table 6-11 for class 1, division 4.

8. When determining intraline and intermagazine distances, use tables 6-3 through 6-5 for class 1, division 1; tables 6-6 through 6-9 for class 1, division 2; table 6-10 for class 1, division 3; and table 6-11 for class 1, division 4.

9. In the application of inhabited building and public traffic route distances, table 6-1, the property boundary will be treated as the governing target, unless manifestly inapplicable (such as unsuitable terrain or land not open to public). In interpreting application to navigable waterways as public traffic routes, occasional small fishing and pleasure boats may be ignored.

C. CLASS 1, DIVISION 1 (MASS DETONATING)

Entire quantities of items in this division can detonate almost instantaneously. Some examples: bulk explosives, some propellants, mines, bombs, demolition charges, torpedo and mission warheads, rockets, palletized projectiles loaded with TNT or Composition B, 8-inch and larger high-capacity projectiles loaded with Explosive D, mass-detonating CBUs, and mass-detonating ammunition components.

NEW Over	Not Over	Distance in Feet to Inhabited Building From			Distance in Feet to Public Traffic Route From		
		Standard Earth-Covered Magazine		Other PES	Standard Earth-Covered Magazine		Other PES
		Front or Side	Rear		Front or Side	Rear	
1	2	3	4	5	6	7	8
0	1	35	25	40	21	15	24
1	2	44	32	50	26	19	30
2	5	60	43	69	36	26	40
5	10	75	54	87	45	32	52
10	20	95	68	110	57	41	65
20	30	110	78	125	65	47	75
30	40	120	86	140	72	51	83
40	50	130	92	150	77	55	89
50	100	160	115	190	97	70	115
100	200	205	145	235	125	88	140
200	300	235	165	270	140	100	160
300	400	260	185	295	155	110	175
400	500	280	200	320	165	120	190
500	600	295	210	340	175	125	205
600	700	310	220	355	185	135	215
700	800	325	230	375	195	140	225
800	900	340	240	390	205	145	235
900	1,000	350	250	400	210	150	240
1,000	1,500	400	285	460	240	170	275
1,500	2,000	440	315	505	265	190	305
2,000	3,000	505	360	580	305	215	350
3,000	4,000	555	395	635	335	240	380
4,000	5,000	600	430	685	360	255	410
5,000	6,000	635	455	730	380	275	440

Table 6-1. Class 1, Division 1: Inhabited Building and Public Traffic Route Distances.

NEW		Distance in Feet to Inhabited Building			Distance in Feet to Public Traffic Route		
Over	Not Over	From			From		
		Standard Earth-Covered Magazine		Other PES	Standard Earth-Covered Magazine		Other PES
		Front or Side	Rear		Front or Side	Rear	
1	2	3	4	5	6	7	8
6,000	7,000	670	480	770	400	285	460
7,000	8,000	700	500	800	420	300	480
8,000	9,000	730	520	835	435	310	500
9,000	10,000	755	540	865	450	325	520
10,000	15,000	865	615	990	520	370	595
15,000	20,000	950	680	1,090	570	405	655
20,000	25,000	1,025	730	1,170	615	440	700
25,000	30,000	1,085	775	1,250	650	465	745
30,000	35,000	1,145	820	1,310	685	490	785
35,000	40,000	1,195	855	1,370	720	515	820
40,000	45,000	1,245	890	1,425	745	535	855
45,000	50,000	1,290	920	1,475	775	555	885
50,000	55,000	1,330	950	1,520	800	570	910
55,000	60,000	1,370	980	1,565	820	585	940
60,000	65,000	1,405	1,005	1,610	845	605	965
65,000	70,000	1,440	1,030	1,650	865	620	990
70,000	75,000	1,475	1,055	1,685	885	635	1,010
75,000	80,000	1,510	1,075	1,725	905	645	1,035
80,000	85,000	1,540	1,100	1,760	925	660	1,055
85,000	90,000	1,570	1,120	1,795	940	670	1,075
90,000	95,000	1,595	1,140	1,825	960	685	1,095

Table 6-1. Class 1, Division 1: Inhabited Building and Public Traffic Route Distances. (continued)

NEW Over	Not Over	Distance in Feet to Inhabited Building From			Distance in Feet to Public Traffic Route From		
		Standard Earth-Covered Magazine		Other PES	Standard Earth-Covered Magazine		Other PES
		Front or Side	Rear		Front or Side	Rear	
1	2	3	4	5	6	7	8
95,000	100,000	1,625	1,160	1,855	975	695	1,115
100,000	110,000	1,740	1,290	1,960	1,045	770	1,175
110,000	120,000	1,855	1,415	2,065	1,110	850	1,240
120,000	125,000	1,910	1,480	2,115	1,145	890	1,270
125,000	130,000	1,965	1,545	2,165	1,180	925	1,300
130,000	140,000	2,070	1,675	2,255	1,245	1,005	1,355
140,000	150,000	2,175	1,805	2,350	1,305	1,085	1,410
150,000	160,000	2,280	1,935	2,435	1,370	1,160	1,460
160,000	170,000	2,385	2,070	2,520	1,430	1,280	1,540
170,000	175,000	2,435	2,135	2,565	1,460	1,280	1,540
175,000	180,000	2,485	2,200	2,605	1,490	1,320	1,565
180,000	190,000	2,585	2,335	2,690	1,550	1,400	1,615
190,000	200,000	2,680	2,470	2,770	1,610	1,480	1,660
200,000	225,000	2,920	2,810	2,965	1,750	1,685	1,780
225,000	250,000	3,150	3,150	1,890	1,890	1,890	1,890
250,000	275,000	3,250	3,250	3,250	1,950	1,950	1,950
275,000	300,000	3,345	3,345	3,345	2,005	2,005	2,005
300,000	325,000	3,440	3,440	3,440	2,065	2,065	2,065
325,000	350,000	3,525	3,525	3,525	2,115	2,115	2,115
350,000	375,000	3,605	3,605	3,605	2,165	2,165	2,165
375,000	400,000	3,685	3,685	3,685	2,210	2,210	2,210
400,000	425,000	3,760	3,760	2,250	2,250	2,250	2,250
425,000	450,000	3,830	3,830	3,830	2,300	2,300	2,300
450,000	475,000	3,900	3,900	3,900	2,340	2,340	2,340
475,000	500,000	3,970	3,970	3,970	2,380	2,380	2,380

Table 6-1. Class 1 Division 1: Inhabited Building and Public Traffic Route Distances. (continued)

NOTES:
1. Distances are computed using the following factors:

NEW	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
0 - 100,000	$35W^{1/3}$	$25W^{1/3}$	$40W^{1/3}$	$21W^{1/3}$	$15W^{1/3}$	$24W^{1/3}$
100,000 - 250,000	$0.3955W^{0.7227}$	$.004125W^{1.0898}$	$2.42W^{0.577}$	$.2375W^{0.7227}$	$.002475W^{1.0898}$	$1.452W^{0.577}$
250,000 - 15 million	$50W^{1/3}$	$50W^{1/3}$	$50W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$

2. The policy contained in Chapter 6, paragraph 6.b.6., shall be employed for mass-detonating, fragment-producing items.
3. The distances for 0 to 50 pounds may be used only when structures, blast mats, etc., can completely confine fragments and debris. Lesser distances may be used only if blast, fragments, and debris can be confined completely, as by certain test-firing barricades.
4. Applies only to earth-covered magazines with dimensions of 26 feet wide and 60 feet long, or larger.

Table 6-1. Class 1, Division 1: Inhabited Building and Public Traffic Route Distances. (continued)

Table 6-2. Minimum Fragment Protection Distances for Selected Class 1, Division 1, Items.

Nomenclature	Distance Required in Feet			
Col 1	Col 2 1 Unit	Col 3 2 Units	Col 4 5 Units	Col 5 10 Units[2]
Bomb, 750 lb, M117A2	690	820	1020	1470
Bomb, 500 lb, Mk82	670	860	1080	1240
Projectile, 175mm, M437A2	450	580	830	2070
Projectile, 155mm, M107	400	510	720	1490
Projectile, 105mm, M1[1]	270	350	500	1000
Projectile, 8 in, Mk25	520	750	960	1240
Projectile, 5 in, Mk49	280	430	660	1000
Torpedoes (Navy) not over 1,500 lbs NEW[3]	500	500	500	500

[1] 105mm projectiles and 105mm complete rounds not in standard storage and shipping containers are class 1, division 1, ammunition.

[2] Ten units or more, until the distance in this table is exceeded by the distance requirements in table 6-1, column 3.

[3] Any torpedoes analogous, in terms of explosive hazard, to Mk16 war shot.

Table 6-3. Class 1, Division 1: Intraline Distances.

NEW		Distance in Feet		NEW		Distance in Feet	
Over Col 1	Not Over Col 2	Bar $D=9W^{1/3}$ Col 3	Unbar $D=18W^{1/3}$ Col 4	Over Col 1	Not Over Col 2	Bar $D=9W^{1/3}$ Col 3	Unbar $D=18W^{1/3}$ Col 4
0	50*	30	60	65,000	70,000	370	740
50	100	40	80	70,000	75,000	380	760
100	200	50	100	75,000	80,000	390	780
200	300	60	120	80,000	85,000	395	790
300	400	65	130	85,000	90,000	405	810
400	500	70	140	90,000	95,000	410	820
500	600	75	150	95,000	100,000	420	840
600	700	80	160	100,000	125,000	450	900
700	800	85	170	125,000	150,000	480	960
800	900	85	175	150,000	175,000	505	1,010
900	1,000	90	180	175,000	200,000	525	1,055
1,000	1,500	105	210	200,000	225,000	545	1,090
1,500	2,000	115	230	225,000	250,000	565	1,135
2,000	3,000	130	260	250,000	275,000	585	1,170
3,000	4,000	145	290	275,000	300,000	600	1,200
4,000	5,000	155	310	300,000	325,000	620	1,240
5,000	6,000	165	330	325,000	350,000	635	1,270
6,000	7,000	170	340	350,000	375,000	650	1,300
7,000	8,000	180	360	375,000	400,000	665	1,330
8,000	9,000	185	370	400,000	500,000	715	1,430
9,000	10,000	195	390	500,000	600,000	760	1,520
10,000	15,000	225	450	600,000	700,000	800	1,600
15,000	20,000	245	490	700,000	800,000	835	1,670
20,000	25,000	265	530	800,000	900,000	870	1,740
25,000	30,000	280	560	900,000	1,000,000	900	1,800
30,000	35,000	295	590	1,000,000	1,500,000	1,030	2,060
35,000	40,000	310	620	1,500,000	2,000,000	1,135	2,270
40,000	45,000	320	640	2,000,000	2,500,000	1,220	2,440
45,000	50,000	330	660	2,500,000	3,000,000	1,300	2,600
50,000	55,000	340	680	3,000,000	3,500,000	1,365	2,730
55,000	60,000	350	700	3,500,000	4,000,000	1,430	2,860
60,000	65,000	360	720	4,000,000	5,000,000	1,540	3,080

*For less than 50 pounds, shorter distances (determined by formulas (above) for columns 3 and 4) may be used when structures, blast mats, etc., can completely contain fragments and debris. When blast, fragments, and debris are confined completely, as by certain test-firing barricades, this table is not applicable.

NEW		Intermagazine Hazard Factors and Distances (Feet)									
Over Col 1	Not Over Col 2	$1.1W^{1/3}$ Col 3	$1.25W^{1/3}$ Col 4	$2W^{1/3}$ Col 5	$2.75W^{1/3}$ Col 6	$4.0W^{1/3}$ Col 7	$4.5W^{1/3}$ Col 8	$5W^{1/3}$ Col 9	$6W^{1/3}$ Col 10	$8W^{1/3}$ Col 11	$11W^{1/3}$ Col 12
0	100	7	7	9	13	18	21	24	28	36	51
100	200	7	7	12	16	24	26	30	35	48	64
200	300	7	8	13	18	26	30	32	40	52	74
300	400	8	9	15	20	30	33	36	44	60	81
400	500	9	10	16	22	32	36	40	48	64	87
500	600	9	11	17	23	34	38	44	51	68	93
600	700	10	11	18	24	36	40	44	53	72	98
700	800	10	12	19	26	38	42	48	56	76	102
800	900	11	12	19	27	38	43	48	58	76	106
900	1,000	11	13	20	28	40	45	50	60	80	110
1,000	1,500	13	14	23	31	46	52	56	69	92	126
1,500	2,000	14	16	25	34	50	57	64	76	100	139
2,000	3,000	16	18	29	40	58	65	72	86	116	158
3,000	4,000	17	20	32	44	64	72	80	95	128	175
4,000	5,000	19	21	34	47	68	77	84	103	136	188
5,000	6,000	20	23	36	50	72	82	92	109	144	200
6,000	7,000	21	24	38	53	76	86	96	115	152	210
7,000	8,000	22	25	40	55	80	90	100	120	160	220
8,000	9,000	23	26	42	57	84	94	104	125	168	230
9,000	10,000	24	27	43	59	86	97	108	130	172	235
10,000	20,000	30	35	55	75	110	120	140	165	220	300
20,000	30,000	35	40	60	85	120	140	160	185	240	340
30,000	40,000	40	45	70	95	140	150	170	205	280	375
40,000	50,000	40	45	75	100	150	170	180	220	300	405
50,000	60,000	45	50	80	110	160	180	200	235	320	430
60,000	70,000	45	50	80	115	165	185	210	245	320	455

Table 6-4. Class 1, Division 1: Intermagazine Hazard Factors and Distances (Use with table 6-5 (for application see paragraph G., below).)

NEW		Intermagazine Hazard Factors and Distances (Feet)									
Over Col 1	Not Over Col 2	$1.1W^{1/3}$ Col 3	$1.25W^{1/3}$ Col 4	$2W^{1/3}$ Col 5	$2.75W^{1/3}$ Col 6	$4.0W^{1/3}$ Col 7	$4.5W^{1/3}$ Col 8	$5W^{1/3}$ Col 9	$6W^{1/3}$ Col 10	$8W^{1/3}$ Col 11	$11W^{1/3}$ Col 12
70,000	80,000	45	55	85	120	170	195	220	260	340	475
80,000	90,000	50	55	90	125	180	200	220	270	360	495
90,000	100,000	50	60	95	135	190	210	230	280	380	510
100,000	125,000	55	65	100	140	200	225	250	300	400	550
125,000	150,000	60	65	105	145	210	240	260	320	420	585
150,000	175,000	60	70	110	155	220	250	280	335	440	615
175,000	200,000	65	75	115	160	230	260	290	350	460	645
200,000	225,000	65	75	120	165	240	270	300	365	480	670
225,000	250,000	70	80	125	175	250	285	320	380	500	695
250,000	300,000	75	85	135	185	270	300	340	400	540	735
300,000	350,000	80	90	140	195	280	320	350	425	560	775
350,000	400,000	80	90	145	205	290	330	370	440	580	810
400,000	450,000	85	95	155	210	310	345	380	460	620	845
450,000	500,000	85	100	160	220	320	360	400	475	640	875
500,000	600,000	95	105	170	230	340	380	420	505	680	930
600,000	700,000	100	110	180	245	360	400	440	535	720	975
700,000	800,000	100	115	185	255	370	420	460	555	740	1,020
800,000	900,000	105	120	195	265	390	435	480	580	780	1,060
900,000	1,000,000	110	125	200	275	400	450	500	600	800	1,100
1,000,000	1,250,000	120	135	215	295	430	485	540	645	860	1,185
1,250,000	1,500,000	125	145	230	315	460	515	570	685	920	1,260
1,500,000	1,750,000	135	150	240	330	480	540	600	725	960	1,325
1,750,000	2,000,000	140	160	250	345	500	570	630	755	1,000	1,385
2,000,000	2,250,000	145	165	260	360	520	590	660	785	1,040	1,440
2,250,000	2,500,000	150	170	270	375	540	610	680	815	1,080	1,495
2,500,000	2,750,000	155	175	280	385	560	630	700	840	1,120	1,540
2,750,000	3,000,000	160	180	290	395	580	650	720	865	1,160	1,585
3,000,000	3,250,000	165	185	295	405	590	670	740	890	1,180	1,630

Table 6-4. Class 1, Division 1: Intermagazine Hazard Factors and Distances (Use with table 6-5 (for application see paragraph G., below).). (continued)

NEW		Intermagazine Hazard Factors and Distances (Feet)									
Over Col 1	Not Over Col 2	$1.1W^{1/3}$ Col 3	$1.25W^{1/3}$ Col 4	$2W^{1/3}$ Col 5	$2.75W^{1/3}$ Col 6	$4.0W^{1/3}$ Col 7	$4.5W^{1/3}$ Col 8	$5W^{1/3}$ Col 9	$6W^{1/3}$ Col 10	$8W^{1/3}$ Col 11	$11W^{1/3}$ Col 12
3,250,000	3,500,000	165	190	305	415	610	680	760	910	1,220	1,670
3,500,000	3,750,000	170	195	310	430	620	700	780	930	1,240	1,710
3,750,000	4,000,000	175	200	315	435	630	715	790	950	1,260	1,745
4,000,000	4,250,000	180	200	325	445	650	730	810	970	1,300	1,780
4,250,000	4,500,000	180	205	330	455	660	740	830	990	1,320	1,815
4,500,00	4,750,000	185	210	335	460	670	760	840	1,010	1,340	1,850
4,750,000	5,000,000	190	215	340	470	680	770	860	1,025	1,360	1,880
5,000,000	5,500,000	195	220	355	485	710	795	880	1,060	1,420	1,940
5,500,000	6,000,000	200	225	365	500	730	820	890	1,090	1,460	2,000
6,000,000	6,500,000	205	235	375	515	750	840	930	1,120	1,500	2,055
6,500,000	7,000,000	210	240	385	525	770	860	960	1,150	1,540	2,105
7,000,000	7,500,000	215	245	390	540	780	880	980	1,175	1,560	2,155
7,500,000	8,000,000	220	250	400	550	800	900	1,000	1,200	1,600	2,200
8,000,000	8,500,000	225	255	410	560	820	920	1,020	1,225	1,640	2,245
8,500,000	9,000,000	230	260	415	570	830	935	1,040	1,250	1,660	2,290
9,000,000	9,500,000	235	265	425	580	850	950	1,060	1,270	1,700	2,330
9,500,000	10,000,000	235	270	430	595	860	970	1,080	1,295	1,720	2,370
10,000,000	11,000,000	245	280	445	610	890	1,000	1,110	1,335	1,780	2,415
11,000,000	12,000,000	250	285	460	630	920	1,030	1,140	1,375	1,840	2,520
12,000,000	13,000,000	260	295	470	645	940	1,060	1,160	1,410	1,880	2,585
13,000,000	14,000,000	265	300	480	665	960	1,085	1,210	1,445	1,920	2,640
14,000,000	15,000,000	270	310	495	680	990	1,110	1,230	1,480	1,980	2,715

Table 6-4. Class 1, Division 1: Intermagazine Harzard Factors and Distances (Use with table 6-5 (for application see paragraph G., below).) (continued)

Table 6-5. Class 1, Division 1: Guide for Intermagazine Distance Table (numbers at intersections identify columns of table 6-4).

		1. Std Earth-covered Magazine (a)				2. Nonstd Earth-covered magazine (b)				3. Above-ground Mag (not earth-covered) (c)		4. Module/ Cell
From / To		a. Side	b. Rear	c. Front - unbarricaded	d. Front - barricaded	a. Side	b. Rear	c. Front - unbarricaded	d. Front - barricaded	a. Un-barricaded	b. Barricaded	
1. Standard Earth-covered Magazine (a)	a. Side	4	4	6	6	4	4	10	10	10	8[e]	4
	b. Rear	4	4	5	5	4	4	10	10	10	8[e]	4
	c. Front unbarricaded	6	5	(d)	(d)	6	5	12	10	12	10	10
	d. Front barricaded	6	5	(d)	(d)	6	5	10	10	10	10	10
2. Nonstandard Earth-covered Magazine (b)	a. Side	4	4	6	6	4	4	10	10	10	10	4
	b. Rear	4	4	5	5	4	4	10	10	10	10	4
	c. Front unbarricaded	10	10	12	10	10	10	12	10	12	10	10
	d. Front barricaded	10	10	10	10	10	10	10	10	10	10	10
3. Above-ground Mag (not earth-covered) (c)	a. Unbarricaded	7	7	12	10	7	7	12	10	12	10	10
	b. Barricaded	7	7	10	10	7	7	10	10	10	10	10
Module/Cell		4	4	10	10	4	4	10	10	10	10	3

NOTES:

(a) Standard earth-covered, arch-type magazines comprise all magazines equal to or stronger than Army igloo magazines; Navy arch-type magazines; and earth-covered, corrugated steel, arch-type magazines (see definition 40., above).

(b) Nonstandard, earth-covered magazines with earth cover equal to or greater than that required by standard, earth-covered, arch-type magazines.

(c) Aboveground magazines are all types of magazines (not earth-covered) and storage pads.

(d) See paragraphs D.1.a. and b., below.

(e) Separation distance of 125 feet is authorized where earth-covered magazine contains only class 1, division 2, A&E.

D. APPLICATION OF INTERMAGAZINE DISTANCES FOR CLASS 1, DIVISION 1, ONLY

1. In applying the intermagazine distances given in table 6-4, consideration must be given to magazine construction and orientation. For earth-covered magazine separation distances, the following conditions apply.

a. When standard earth-covered magazines containing class 1, division 1, ammunition are sited so that any one is in the forward section, 60 degrees either side of the centerline of another, the two must be separated by distances greater than the minimum permitted for side-to-side orientations. The greater distances primarily protect door and headwall structures against blast from a potential explosion site forward of the exposed magazine. When a blast wave is reflected from a surface at other than grazing incidence (side-on orientation), the overpressure may be increased substantially over the free-field value. High reflected pressure impulse can damage doors and headwalls and propel the debris into the igloo, communicating the explosion to the contents on impact. Some examples of the application of these rules follow:

(1) If headwalls of both A and B are outside the 120-degree sector (60 degrees either side of the centerline), they may be separated by the column 4 distances based on the largest quantity of class 1, division 1, stored in either. This is considered the equivalent of standard side-to-side separation with the optimum orientation -- all igloos facing the same direction and axes parallel (see figures 6-1 and 6-2).

(2) If headwall of A is outside the 120-degree sector of B, but headwall of B is inside the 120 degree sector of A, separation distance between these two igloos is determined by column 6, based on the largest quantity of class 1, division 1, in either igloo. However, if the quantity in B were reduced to less than 1/10 of that in A, or if the storage in B is not class 1, division 1, igloo A would control as a potential explosion site. Then, in accordance with Chapter 4, paragraph B, the distance must be taken from column 4, based on the quantity in A; that is, the quantity in A would not need to be reduced (see figure 6-3).

(3) If headwalls of A and B are within the 120-degree sector of each other and are not provided with a separate door barricade, table 6-4, column 12, distances must be used to separate them. If a door barricade is present (meeting requirements of paragraph D.5., Chapter 4) such as A to C, then column 10 distances may be used to determine separation distances (see figure 6-4).

(4) Although no separate barricade is shown between A and B, more detailed analysis of a specific storage condition of this type might show that the distribution of explosives within A and B is such that the earth fill of one or the other or both meets the specifications of an effective barricade according to Chapter 4, paragraph D.1.b.(5). In such a case, column 10 distances would apply between A and B (see figure 6-4).

(5) Two additional standard igloo orientations warrant analysis:

(a) Igloos A and B significantly differ in length (figure 6-6) or are "canted" in such a manner (figure 6-5) that one of them is within the 120-degree sector off the headwall of the other, even though a straight line between headwall A and igloo B does pass through the earth cover of B (see figure 6-5).

(b) If B is the potential explosion site and A is the exposed site, the limit for B would be determined by column 7. With A as the potential explosion site, however, the limit for A would be based upon column 4. Igloo B may be used to its physical capacity for hazard divisions other than 1.1.

b. When considering relationships between standard earth-covered magazines and aboveground magazines or facilities requiring intraline distances, each containing class 1, division 1, ammunition or explosives, the question regarding the use of barricaded or unbarricaded distances arises. The following criteria will apply:

(1) Aboveground magazines or facilities requiring intraline distances within the 120-degree sector in front of a standard earth-covered magazine will be provided unbarricaded distances, unless a separate effective intervening barricade meeting requirements of Chapter 4, paragraph D.1.b.(5), is present, in which case barricaded distances may be applied (see figure 6-7).

(2) Aboveground magazines or facilities requiring intraline distances outside of the 120-degree sector in front of a standard earth-covered magazine will be provided with barricaded distances whether or not a separate intervening barricade is present (see figure 6-7).

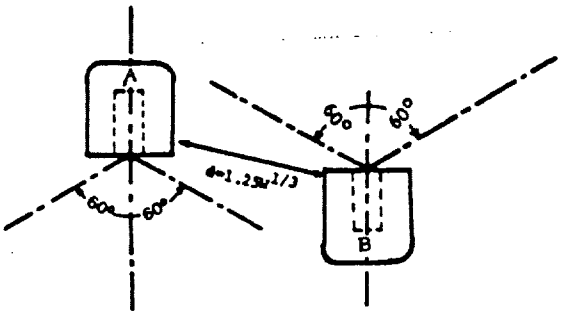


Figure 6-1.

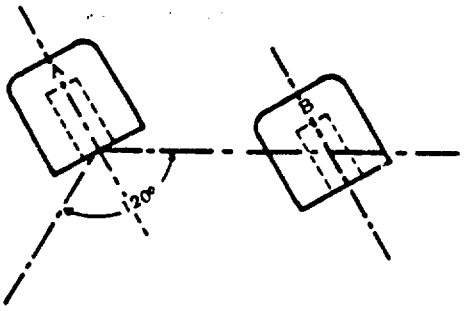


Figure 6-2.

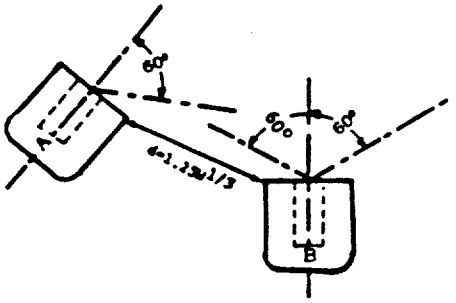


Figure 6-3.

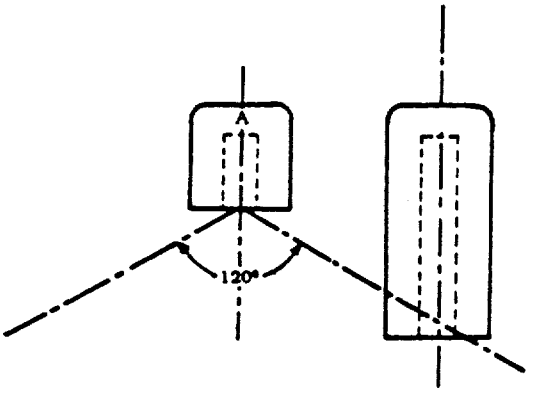


Figure 6-4.

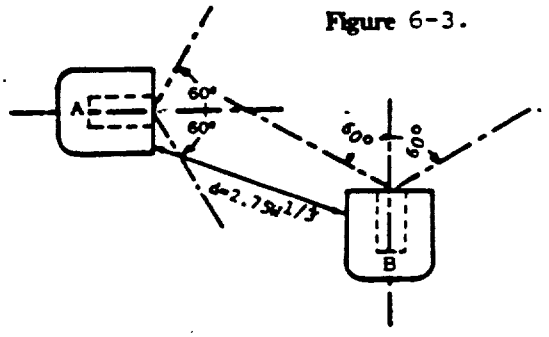


Figure 6-5.

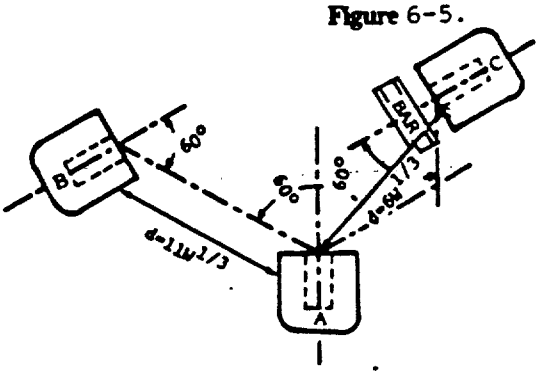


Figure 6-6.

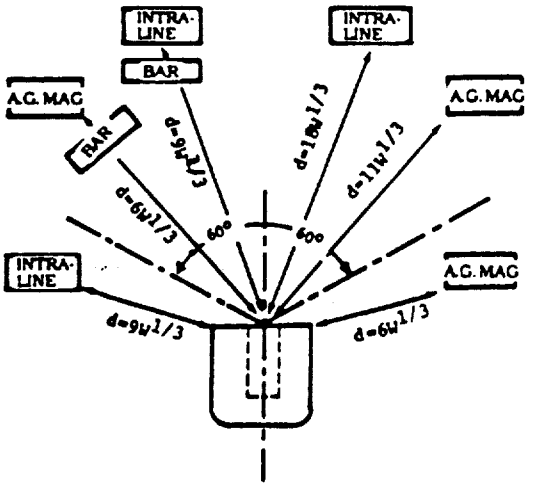


Figure 6-7.

2. Distances in column 4 apply to nonstandard, earth-covered magazines oriented so that all straight lines between the side and rear walls of two magazines pass through an earth-covered surface of each; similarly, column 10 distances apply to all orientations in which every straight line between two magazines passes through the earth cover of one and only one of them. If the above conditions cannot be met, column 12 distances apply. The earth cover of nonstandard magazines must be equal to or greater than that required for standard earth-covered, arch-type magazines.

3. Other factors limiting igloo magazine storage are as follows:

a. Igloo magazines that are equivalent in strength to the requirements of paragraphs D.1., D.2., and D.3., Chapter 4, are limited to 500,000 pounds NEW. Igloo magazines not equivalent in strength to those requirements are limited to 250,000 pounds NEW.

b. Quantities above 500,000 pounds NEW in one storage location are not authorized except for liquid propellants.

c. The distance given for 0 to 100 pounds NEW constitutes the minimum magazine spacing permitted.

4. Examples given in paragraphs D.1.a.(1) through (6), above, apply only to the storage of class 1, division 1, ammunition and explosives. Existing earth-covered magazines, regardless of orientation, meeting the construction and barricading requirements of Chapters 5 and 7 (and sited for any quantity of class 1, division 1) may be used to their physical capacity for the storage of class 1, divisions 2, 3, and 4, A&E.

E. CLASS 1, DIVISION 2 (NONMASS-DETONATING, FRAGMENT PRODUCING)

1. Items in this division are those for which the principal hazards are fragment and blast, either individually or in combination, depending on such factors as storage configuration, type of packing, and quantity. The designated minimum distances that are specified are based on the limiting range of fragments for which protection by distance is to be provided and shall be used for inhabited building and public traffic route distances. Most fragments produced by incidents in this division will fall within one of the four specified minimum distances, that is, 400, 800, 1,200, and 1,800 feet.

2. The fragment hazard from items within a specified minimum distance category varies with existing conditions, but is essentially the same for one as for many items or components. For these items, the required separation distances are influenced heavily by packing, state of assembly, charge/weight ratio, and caliber. Items in this division usually explode progressively when involved in a fire or otherwise initiated. Therefore, the distances prescribed will not be lessened if the quantity to be stored is less than the maximum quantity specified by the appropriate table.

Table 6-6. Category (04), Class 1, Division 2.[1]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
No limit specifically required for safety reasons	400	240	200	200	(See note[2])

List of items (examples only): Small arms ammunition with explosive projectiles; 20mm ammunition with explosive projectiles; fixed ammunition with nonexplosive projectiles when caliber and packing limit the hazard in accordance with this class; WP smoke hand grenades; and nonmass-detonating CBUs[2].

[1]Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangers and manufacturing or operating buildings, without regard to Q/D. Examples: small destructors, fuzes, and firing devices.

[2]Earth-covered buildings may be used to their physical capacity for this category of material, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

Table 6-7. Category (08), Class 1, Division 2.

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
No limit specifically required for safety reasons	800	480	400[1]	300	(See note[2])

List of items (examples only): Fixed and semifixed ammunition, rockets and rocket components, and nonmass-detonating CBUs.

[1]If the high explosives in (08)1.2 items at an operating line PES are limited to 5,000 pounds, intraline distance may be reduced to 200 feet.

[2]Earth-covered buildings may be used to their physical capacity for this category of material, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

Table 6-8. Category (12), Class 1, Division 2.[1, 2]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
500,000	1,200	720	600[2]	300	(See note[3])

List of items (examples only): Separate projectiles with explosive "D" filler, except high capacity types, caliber 8 inch or larger; fixed and semifixed ammunition; nonmass-detonating cluster bomb units (CBUs); rockets, rocket motors, and nonmass-detonating rocket heads.

[1] Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustible containers. Storage in earth-covered magazines is therefore preferred.

[2] If the high explosives in (12)1.2 items at an operating line PES is limited to 5,000 pounds, intraline distance may be reduced to 200 feet.

[3] Earth-covered buildings may be used to their physical capacity for this class of material, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

Table 6-9. Category (18), Class 1, Division 2.[1, 2]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
500,000	1,800	1,080	900	300	(See note[2])

List of items (examples only): Nonmass-detonating high explosive-loaded projectiles; fixed and semifixed ammunition; and rockets and rocket heads.

[1] Items of this category present a risk of propagation to adjacent aboveground magazines, particularly when packed in combustible containers. Storage in earth-covered magazines is therefore preferred.

[2] Earth-covered buildings may be used to their physical capacity for this category of material, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

F. CLASS 1, DIVISION 3 (MASS FIRE)

Items in this division burn vigorously with little chance of being extinguished in storage. Explosions will normally be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast overpressure beyond the magazine distance specified in table 6-10. A severe hazard of the spread of fire may result from burning container materials, propellant, or other flaming debris being tossed about by the force of pressure ruptures.

Table 6-10. Class 1, Division 3.[1]

NEW (Over)	NEW (Not Over)	Public Building Distance (feet)	Traffic Route Distance (feet)	Magazine Distance	
				Aboveground Magazine Intraline (feet)	Earth-covered (feet)
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
0	1,000	75	75	50	(See note[2])
1,000	5,000	115	115	75	
5,000	10,000	150	150	100	
10,000	20,000	190	190	125	
20,000	30,000	215	215	145	
30,000	40,000	235	235	155	
40,000	50,000	250	250	165	
50,000	60,000	260	260	175	
60,000	70,000	270	270	185	
70,000	80,000	280	280	190	
80,000	90,000	295	295	195	
90,000	100,000	300	300	200	
100,000	200,000	375	375	250	
200,000	300,000	450	450	300	
300,000	400,000	525	525	350	
400,000	500,000	600	600	400	
500,000	1,000,000[3]	800	800	500	

List of items (examples only): Military pyrotechnics; solid propellants in bulk, in containers, or in ammunition items; nontoxic chemical ammunition.

[1] Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangars and manufacturing or operating buildings, without regard to Q/D. Examples: document-destruction and signaling devices and riot control munitions.

[2]Earth-covered buildings may be used to their physical capacity for this division, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

[3]For determining distances to be used in event special requirements exist for amounts above one million pounds, the values given above will be extrapolated by means of cube-root scaling as follows:

For inhabited building and public traffic route distances: $D=8W^{1/3}$
For aboveground magazine and intraline distances: $D=5W^{1/3}$

G. CLASS 1, DIVISION 4 (MODERATE FIRE, NO BLAST)

Items in this division present a fire hazard with no blast hazard and virtually no fragmentation hazard beyond the fire hazard clearance ordinarily specified for high risk materials. Separate facilities for storage and handling of this division should not be less than 100 feet from other facilities, except those of fire-resistive construction, which may be 50 feet from each other.

Table 6-11. Class 1, Division 4.[1, 2]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
No limit specifically required for safety reasons	100	100(2)	Appropriate fire protection distance	50 (100 if combustible construction)	No specified separation requirement

List of items (examples only): Small arms ammunition without explosive projectiles, fuse lighters and squibs, distress signals, 20mm ammunition without explosive projectiles, colored smoke grenades, and explosive valves or switches.

[1]With reasonable care, class 1, division 4, items may be stored in an area for general supplies in any weatherproof warehouse, provided these warehouses storing division 4 ammunition are separated from all other warehouses by at least the aboveground magazine separation distance specified.

[2]Limited quantities of class 1, division 4, items may be stored in facilities such as hangars and manufacturing or operating buildings without regard to Q/D. Examples: small arms ammunition, riot control munitions, and pyrotechnics for security purposes. Also, small magazines used for similar purposes may be separated by appropriate fire protection distances.

H. INSENSITIVE HIGH EXPLOSIVES (IHE)

1. IHE comprise class/division 1.1 explosive substances that, although mass-detonating, are so insensitive that there is negligible probability of initiation or transition from burning to detonation in transport or in storage.

2. Insensitive high explosives ammunition contains IHE substances and has demonstrated through test results (paragraph L., below) that the ammunition case has negligible mass and confinement effects on the probability of initiation or transition from burning to detonation of the IHE in transport or storage. Such ammunition when intentionally initiated will be incapable of transferring detonation to another (that is, propagating).

I. TEST PROCEDURES DOCUMENTS

These documents set forth procedures to be used in the IHE and IHE ammunition testing required by paragraph J. through L., below.

1. TB = DoD Hazard Classification Procedures (TB 700-2, NAVSEA INST 8020.8, TO11A-1-47, DLAR 8220.1) (reference (e)).

2. JSSPM = Joint Services Safety and Performance Manual (reference (f)).

3. WR 50 = Warhead Safety Tests, Minimum for Air, Surface and Underwater Launched Weapons (reference (g)).

4. JMEM = Joint Munitions Effectiveness Manual, Air-To-Surface Joint Service Test Procedures for Bombs and Bomblets - NAVAIR 00-130-ASR-2-1 (reference (h)).

J. SCREENING TESTS FOR IHE

Substances that are candidates for designation as IHE shall be subjected to the screening tests specified below. Failure to achieve required results in a single test should not be regarded as disqualifying, provided all other results are achieved. However, it does signal the need for careful evaluation.

Test Procedures

Test	Document	Required Results
Impact	TB	Sensitivity less than Explosive D
Friction	JSSPM	No reaction
Differential thermal analysis (DTA)	JSSPM	No exotherm at 250°C
Small scale burn	TB	No detonation or violent reaction
Spark	JSSPM	No reaction at 0.25 joule

K. QUALIFICATION TESTS FOR IHE

On the basis of screening test results stated in paragraph J., above, substances deemed legitimate candidates for designation as IHE shall pass tests specified in table 6-12.

L. QUALIFICATION TESTS FOR IHE AMMUNITION

Ammunition containing insensitive high explosives must pass tests specified in table 6-13 to qualify as IHE ammunition. In addition, it must be demonstrated by an actual test, that intentional detonation of item will be incapable of propagating detonation to another like item.

M. HAZARD CLASSIFICATION AND COMPATIBILITY GROUPS

Table 6-14 provides examples of the relationship between storage compatibility groups, Q/D divisions, and DOT classes for item classified in accordance with TB 700-2 (reference (e)). Tables 6-15 and 6-16 assign Q/D divisions and storage compatibility groups to substances qualified as IHE under the provisions of paragraph K., above, and to ammunition qualified as IHE ammunition under provisions of paragraph L., above.

N. Q/D STANDARDS AND POLICIES FOR AIRFIELDS

1. These provisions do not apply to explosives items installed on aircraft or contained in survival and rescue kits such as signals, flares, egress systems components, squibs and detonators for jettisoning external stores, engine starter cartridges, fire extinguisher cartridges, destructors in electronic equipment, explosives components of emergency kits and equipment, and other such items or materials necessary for safe flight operations.

2. These Q/D standards will be applied:

a. To any airfield at which A&E are handled or stored.

b. In conjunction with airfield clearance criteria as prescribed by DoD Components and Federal Aviation Regulation (reference (b)). Airfields, heliports, and seadromes not used exclusively by DoD Components, combat aircraft parking areas, ammunition and explosives cargo areas, alert hangars, and shelters shall be located as prescribed in table 6-17.

c. In separating ammunition and explosives facilities from inhabited buildings, public traffic routes, and other ammunition and explosives facilities, in accordance with Chapters 4 and 6.

3. In applying the standards prescribed in table 6-17, distances shall be measured as follows:

a. Loaded aircraft to loaded aircraft. Measure the distance from explosives on one aircraft to explosives on adjacent aircraft.

b. Ammunition and explosives location to taxiways and runways. Measure from the nearest point of the A&E location to the nearest point of the taxiway and to the centerline of the runway.

4. Separation distances between the following areas and from these areas to other targets shall be determined by applying table 6-17:

a. A&E cargo areas.

b. A&E storage facilities.

c. A&E operating facilities.

5. A&E shall be prohibited under approach/departure zones of fixed and rotary wing aircraft landing facilities. The approach/departure zones for aircraft (surfaces or areas) are described in detail in airfield and airspace criteria directives of the DoD Components. In general, approach/departure zones begin near the end of a runway or landing area and extend outward to a given distance along, and symmetrically on each side of, the extended runway centerline or the aircraft approach axis of a heliport. Such zones flare uniformly from the landing area outward to a prescribed limit.

Test	Test Procedures Document	No. of Trials	Sample[1]	Required Results
Critical diameter test	JSSPM		$L_s/D_s = 4$ D_s(inches) increased in 1 inch increments (1,2,3, etc.)	Critical diameter[2] - minimum diameter sample for steady state detonation
Cap test	TB	5	$L_s/D_s = 4$ $D_s = 3xD_c$	No reaction
Card gap test	TB		D_s = (see note [3] below)	See note [4]
Slow cook-off test	WR-50	3	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque)	No detonation or violent reaction with fragment throw
External fire test	TB	1	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque)	No detonation or violent reaction with fragment throw
Susan test	JSSPM	3		Less than 10% TNT equivalent output
Bullet impact test	JSSPM	6	$L_s/D_s = 4$; $D_s = 3xD_c$ (confined in Sched 40 pipe, capped at 150 ft-lb torque) 3 trials in axial orientation and 3 trials in longitudinal orientation	No reaction when impacted by 0.50 caliber projectile

Table 6-12. Qualification Tests for IHE.

[1] L_s = Sample length; D_s = Sample diameter

[2] D_c = Critical diameter

[3] The test sample shall have a length to diameter ratio of 3.83 when the sample diameter is either 1.44 inches or 2.94 inches depending, respectively, upon whether the test material has a confined $D_c \leq 72$ in. or 0.72 in. $< d_c \leq 1.47$ in.

[4] When a substance has an unconfined or confined $D_c \leq .72$ in., it shall be tested at a gap of .69 inches. Should the substance detonate during any trial, it may not be classed as an IHE. When a substance has a confined critical diameter 0.72 in. $< D_c \leq 1.44$ in., it shall be tested at a gap that correlates to the .69 in. gap for the smaller diameter test. Should the substance detonate during any trial, it may not be classed as an IHE.

Table 6-12. Qualification Tests for IHE. (continued)

Test	Test Procedures Document	Sample	Stimulus	Required Result
Sled test	JMEM	All-up round/ w/o overpack velocity	Impact hard surface at 450 meters per second	No detonation
Bonfire	TB	Ammo in storage & shipping configuration	Open fire	No detonation
Propagation	WR-50	Ammo in storage & shipping configuration	Detonated all-up round in storage/shipping configuration	No propagation of detonation
Slow cook-off	WR-50	Ammo in storage & shipping configuration	Heat to reaction temperature	No detonation or violent reaction with fragment throw
Multiple bullet impact	WR-50	All-up round in 3 different orientations	.50 cal AP ammo fired at service velocity in 3-round bursts	No detonation

Table 6-13. Qualification Tests for IHE Ammunition.

Items	SCG	Q/D Class 1 Division	DOT Class
1. Initiating explosives	A	1	A
2. Detonators and similar initiating devices	B	1, 2, or 4	A or C
3. Bulk propellants, propelling charges, and devices containing propellant with or without means of ignition	C	1, 2, 3, or 4	A, B, or C
4. Black powder, high explosives, and HE ammunition without its own means of initiation and without a propelling charge	D	1 or 2	A
5. HE ammunition without its own means of initation, with a propelling charge	E	1 or 2	A
6. HE ammunition with its own means of initiation, with or without a propelling charge	F	1 or 2	A
7. Fireworks and illuminating, incendiary, smoke, or tear producing ammunition other than ammunition that is activated by exposure to water or the atmosphere	G	1, 2, 3, or 4	A, B, or C
8. Ammunition containing both explosives and white phosphorous or other pyrophoric material	H	2 or 3	A or B
9. Ammunition containing both explosives and flammable liquid or gel filler	J	3	B
10. Ammunition, not included in other groups, requiring separate storage	L	1, 2, 3, or 4	A, B, or C
11. Ammunition that presents no significant hazards	S	4 or none	C or exempt

Table 6-14. Hazard Classifications/Compatibility Groups.

Table 6-15. IHE Hazard Classifications/Compatibility Groups.*

IHE stored alone	1.3c
IHE stored at magazine distance or greater from class 1.1	1.3c
IHE stored at magazine distance or greater from class 1.2	1.3c
IHE stored with 1.1c items	1.1c
IHE stored with 1.2c items	1.1c
IHE stored with other 1.3c items	1.3c
IHE stored with 1.4c items	1.3c
IHE stored at less than magazine distance from class 1.1	1.1c
IHE stored at less than magazine distance from class 1.2	1.1c

Table 6-15. IHE Ammunition Hazard Classification/Compatibility Groups.*

Warheads certified as invulnerable to accidental detonation by arming and firing system	1.4d
Warheads not certified as invulnerable to accidental detonation by arming and firing system	1.2d
All-up rockets with 1.3 motors and warheads certified as invulnerable to accidental detonation by arming and firing system	1.3c
All-up rockets with 1.3 motors and warheads not certified as invulnerable to accidental detonation by arming and firing system	1.2e

*When stored with compatible items of other Q/D classes, the most restrictive Q/D class will apply to the combination.

Table 6-17. Q/D Standards for Mass-Detonating Ammunition and Explosives (Class 1, Division 1).

Over (Pounds)	Not Over (Pounds)	Distance in feet for specific targets[1]
Col 1	Col 2	Col 3
0	50[2]	110
50	100	140
100	200	175
200	300	200
300	400	220
400	500	240
500	600	255
600	700	265
700	800	280
800	900	290
900	1,000	300
1,000	1,500	345
1,500	2,000	380
2,000	3,000	435
3,000	4,000	480
4,000	5,000	515
5,000	6,000	545
6,000	7,000	575
7,000	8,000	600
8,000	9,000	625
9,000	10,000	645
10,000	15,000	740
15,000	20,000	815
20,000	25,000	875
25,000	30,000	935
30,000	35,000	980
35,000	40,000	1,025
40,000	45,000	1,070
45,000	50,000	1,105
50,000	55,000	1,140
55,000	60,000	1,175
60,000	65,000	1,205
65,000	70,000	1,235[3]
70,000	75,000	1,265
75,000	80,000	1,295

[1] To protect against low-angle, high-speed fragments, barricades should be provided; however, these distances will not be reduced.

[2] The distance given for 0 to 50 pounds NEW constitutes the minimum spacing permitted.

[3] The minimum distance for class 1, division 1, to 1,250 feet (see Chapter 6, paragraph B.6.d.) does not apply to targets covered by this table.

Table 6-17. Q/D Standards for Mass-Detonating Ammunition and Explosives (Class 1, Division 1). (continued)

80,000	85,000	1,320
85,000	90,000	1,345
90,000	95,000	1,370
95,000	100,000	1,390
100,000	125,000	1,500
125,000	150,000	1,595
150,000	175,000	1,675
175,000	200,000	1,755
200,000	225,000	1,825
225,000	250,000	1,890
250,000	275,000	1,950
275,000	300,000	2,005
300,000	325,000	2,065
325,000	350,000	2,115
350,000	375,000	2,165
375,000	400,000	2,210
400,000	425,000	2,250
425,000	450,000	2,300
450,000	475,000	2,340
475,000	500,000	2,380

		TO											
		Combat Aircraft Parking Area	Ammunition/Explosives Cargo Area	Ammunition/Explosives Storage Facility	Ammunition/Explosives Operating Facility	Ready Ammunition Storage Facility	Inhabited Building	Public Traffic Route	Runway/Taxiway (Joint DoD/Non-DoD Use)	Runway/Taxiway (DoD Component Use Only)	Aircraft Parking Area	Aircraft Passenger Loading/Unloading Area	Recreation Area
FROM	Combat Aircraft Parking Area	3*	3*	3	4	3	1	2	2	None	10	7	8
	Ammunition/Explosives Cargo Area	3*	3*	3	4	3	1	2	2	None	10	7	9
	Ammunition/Explosives Storage Facility	5	3	3	4	3	1	2	2	11	6	7	9
	Ammunition/Explosives Operating Facility	5	3	3	4	3	1	2	2	11	6	7	9
	Ready Ammunition Storage Facilities	3*	3*	3	4	3	1	2	2	None	10	7	8

NOTE:

* This distance will protect against simultaneous detonation of ammunition on adjacent aircraft, but will not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire.

Table 6-18. Application of Ammunition and Explosives Safety Distances.

KEY TO TABLE 6-18

1. Use appropriate inhabited building distance.

2. Use appropriate public traffic route distance.

3. Use appropriate intermagazine distance.

4. Use appropriate intermagazine distance which will, in this case, protect against simultaneous detonation of ammunition or adjacent aircraft, but will not prevent serious damage to aircraft and possible propagation of detonation due to fragments, debris, or fire.

5. Use appropriate intraline distance.

6. Use table 6-17 distances for mass-detonating items and appropriate public traffic route distances for nonmass-detonating items.

7. Use table 6-1 distances for DoD Component aircraft parking areas, and appropriate inhabited building distance for non-DoD Component aircraft parking areas.

8. Use appropriate public traffic route distances for locations in the open where passengers emplane and deplane; use appropriate inhabited building distance if a structure is included where passengers assemble, such as a passenger terminal building.

9. No distance required to recreational areas used exclusively for alert personnel manning the combat-loaded aircraft. Other recreational areas where people are in the open shall be at appropriate public traffic route distance. When structures, including bleacher stands, are in such areas, appropriate inhabited building distance shall be used.

10. Recreational areas, where people are in the open, shall be at appropriate public traffic route distance. When structures, including bleacher stands, are in such areas, appropriate inhabited building distance shall be used.

11. Within these areas of airfields, heliports, and seadromes exclusively used by DoD Components, the separation of aircraft parking areas from combat aircraft parking areas and their ready ammunition storage facilities and ammunition/explosives cargo areas are considered to be a command function. At joint DoD/non-DoD-use airfields, heliports, and seadromes, the combat aircraft parking areas and its ready ammunition storage facilities and ammunition and explosives cargo area will be separated from non-DoD aircraft as specified in paragraph 7., above.

12. Use $18w^{1/3}$ distances from side or rear of standard earth-cover magazine containing mass-detonating items to taxiway; use appropriate public traffic route distance from side or rear of standard earth-covered magazine containing nonmass-detonating items to taxiway; use appropriate public traffic route distance from front of standard earth-covered magazines, and nonmass-detonating items to runway.

CHAPTER 7

LIQUID PROPELLANTS STANDARDS

A. APPLICATION

1. These criteria establish Q/D, storage compatibility groupings, and high explosives equivalencies for liquid propellants. They apply to liquid propellant storage facilities (including missiles, rockets, and multicompartment tanks in which both liquid fuels and liquid oxidizers are stored).

2. If hazard classifications and storage compatibility groups for liquid propellants are not listed in table 7-1, they may be obtained from the PCO.

B. DETERMINATION OF PROPELLANT QUANTITY

1. For Q/D purposes, the net weight of propellant in a tank, drum, cylinder, or other container will be used. The quantity of propellant in associated piping (to the point(s) providing means for interrupting the flow in an incident) must be included in the net weight of propellant in a storage container.

2. When incompatible propellants are not separated by distances prescribed in tables 7-2, 7-3, and 7-4; or provisions for preventing their mixing are not available, the combined quantity of the two must be used with appropriate HE equivalency (table 7-5) to determine the Q/D (table 7-6).

3. Table 7-7 lists conversion factors (gallons to pounds) for the various liquid propellants.

C. MEASUREMENT OF SEPARATION DISTANCES

1. Separation distances will be measured from the nearest hazard source (containers, buildings, or positive cutoff point in piping, whichever is controlling).

2. If a building contains a small number of drums or cylinders, or if quantities of propellant in the building are subdivided effectively, distances may be measured from the nearest container or controlling subdivision.

D. Q/D CONSIDERATIONS

1. Q/D criteria in this section are based on these premises: construction materials will be compatible with propellants to which they may be exposed; design will take into account the properties of the propellant; required fire protection and drainage controls will be provided; and other special controls (such as nitrogen padding, tank cooling, etc.) will be provided when required.

2. If group I, II, and III propellants are contaminated, tables 7-2, 7-3, and 7-4 are not applicable. In such cases, group IV Q/D requirements will apply except when the PCO specifically approves other criteria.

E. HAZARD GROUPING

Liquid propellants present various types and degrees of hazards. The following propellant groupings are based on these hazards.

1. Group I. Considered the least hazardous, these materials have a fire hazard potential and require separation distance as specified in table 7-2. When group I materials are stored with more hazardous materials under conditions described in paragraph F., below, tables 7-5 and 7-6, will determine Q/D requirements.

2. Group II. Strong oxidizers, these materials may cause serious fires when they come into contact with material such as organic matter. Table 7-3 specifies quantity limitations and minimum distance requirements. When group II materials are stored with more hazardous materials under conditions described in paragraph F., below, tables 7-5 and 7-6 will determine Q/D requirements.

3. Group III. Hazardous fragmentation of the container, its protective structure, or other nearby material may be produced by pressure rupture of the storage container or a vapor-phase explosion. Table 7-4 specifies quantity limitations and minimum distance requirements for this group. When group III materials are stored with more hazardous materials, under conditions described in paragraph F., below, tables 7-5 and 7-6 will determine Q/D requirements.

4. Group IV. These hazards are the same as for mass-detonating explosives (such as airblast overpressure and fragments from the containers and surrounding equipment and material). Table 7-6 will determine Q/D requirements.

F. HAZARDS

Aside from the fact that the propellants differ from each other, as explained for the above groups, the predominant hazard of the individual propellant varies according to the location of the propellant storage and the operation(s) involved. These conditions follow, in order of decreasing hazard:

1. Range Launch Pads. Activities at range launch pads include research, development, and testing. The proximity of fuel to oxidizer, the frequency of launchings and the possibility of fall-back (with resultant dynamic mixing on impact) make operations at these facilities very hazardous. Explosives equivalents (table 7-5) must be used to determine Q/D (table 7-6).

2. Static Test Stands. Although these can involve experimental operations, the units remain static and are subject to better control than dynamic ones. Except when run tankages for fuel and oxidizer are mounted one above the other, it is possible to separate the tankages to reduce the hazard. Except as provided in paragraph G., below, explosives equivalents (table 7-5) must be used to determine Q/D (table 7-6).

3. Ready Storage. Ready storage may be located at a minimum of intraline distance from launch and static test stands, based on the propellant requiring the greater distance. Normally, propellant from ready storage is not fed directly into an engine, as is the case with run tankage (see paragraph F.8., below). HE equivalents (table 7-5) must be used for propellants in ready storage if the facility design does not guarantee against fuel and oxidizer mixing

and against propagation to, or initiation at, the ready storage facility when a mishap occurs at the test stand or launch pad. If prevention of detonation of ready storage is assured, Q/Ds will be based on the prevailing fire or fragment hazards (table 7-2, 7-3, or 7-4).

4. Cold-Flow Test Operations. Fire and fragment hazards (tables 7-2, 7-3, and 7-4) govern if the system is closed (except for approved venting) and completely airtight; if fuel and oxidizer are never employed concurrently, each has an isolated system, and fittings are such that intermixing is impossible; and if the propellants are of required purity. Otherwise, HE equivalents (table 7-5) must be used to determine Q/Ds (table 7-6).

5. Bulk Storage. This is the most remote storage with respect to launch and test operations, never being directly connected to any of them. It consists of the area, tanks, and other containers therein, used to hold propellant for supplying ready storage and, indirectly, run tankage where no ready storage is available. Individual bulk storage facilities must be separated from each other and from unrelated exposures in accordance with tables 7-2, 7-3, 7-4, and 7-6. If positive measures are not taken to prevent mixing of group I, II, and III fuels and oxidizers, TNT equivalents (table 7-5) must be used to determine Q/Ds (table 7-6).

6. Rest Storage. This temporary storage resembles bulk storage. Barges, trailers, tank cars, and portable hold-tanks (used for topping operations) may be used as rest storage facilities. Fire and fragment hazards (tables 7-2, 7-3, and 7-4) govern. The transporter becomes a part of that storage to which it is connected during propellant transfer.

7. Run Tankage (Operating Tankage). Run tankage (operating tankage) consists of the tank and/or other containers and associated piping used to hold the propellants for direct feeding into the engine or device during operations (see paragraph F.3., above).

8. Pipelines. A distance of 25 feet free of inhabited buildings will be maintained on either side of the pipelines used for the transfer of group II and III propellants between unloading points and storage areas or between storage areas and points of use.

G. INCOMPATIBLE STORAGE

Except where effectively subdivided by intervening barriers or other positive means for preventing mixing, separation distance between propellants of different compatibility groups will be the inhabited building distance for the propellant quantity and group that requires the greater distance. Where prevention of mixing is assured, incompatible storages will be separated from each other by intragroup distance. If different hazard groups are involved, the group requiring the greater distance will be controlling.

H. COMPATIBLE STORAGE

Compatible storage of propellants of different hazard groups will be separated from other exposures by the greater intragroup storage distance (see table 7-1).

Table 7-1. Liquid Propellants Hazard and Compatibility Groupings.

Propellant	Hazard group[1]	Compatibility storage group[2]
Alcohols CH_3OH, C_2H_5OH, $(CH_3)_2CHOH$	I	C
Anhydrous Ammonia NH_3	I	C
Aniline $C_6H_5NH_2$	I	C
Hydrocarbon Fuels JP-4, JP-5, RP-1	I	C
Monopropellant NOS-58-6	I	C
Nitrogen Tetroxide N_2O_4	I	A
Otto Fuel II	I	G
Red Fuming Nitric Acid HNO_3	I	A
Bromine Pentafluoride BrF_5	II	A
Chlorine Trifluoride ClF_3	II	A
Hydrogen Peroxide Greater than 52% H_2O_2	II[3]	A
Liquid Fluorine LF_2	II	A
Liquid Oxygen LO_2	II	A
Perchloryl Fluoride ClO_3F	II	A
Oxygen Difluoride OF_2	II	A
Ozone Difluoride O_3F_2	II	A
Ethylene Oxide C_2H_4O	III	D
Hydrazine N_2H_4	III	C
Hydrazine-UDMH Mixtures	III	C
Liquid Hydrogen LH_2	III	C
Mixed Amine Fuels	III	C
Monomethylhydrazine CH_3NHNH_2	III	C
Pentaborane B_5H_9	III	D
Triethyl Boron $B(C_2H_5)_3$	I	D
UDMH $(CH_3)NNH_2$	III[5]	C[4]
Nitromethane CH_3NO_2	IV	F
Tetranitromethane $C(NO_2)_4$	IV	F

[1]For some of the materials listed, the toxic hazard may be an overriding consideration. Consult applicable regulations and, if necessary, other authorities or publications for determination of toxic siting criteria.

[2]All propellants in a compatibility group are considered compatible. Groupings are not to be confused with ammunition and explosives compatibility groupings with like letters.

[3]Under certain conditions, this propellant can detonate. However, its sensitivity to detonation is not greater than that of a standard energetic double base solid propellant under the same conditions.

[4]Nitromethane is chemically compatible with compatibility storage group C liquid propellants, but due to differences in hazards should be stored separately.

[5]Technical grade nitromethane in unit quantities of 55 gallons or less in DOT 17E or C drums may be stored as Hazard Group II provided the following apply:

a. Drums are stored only one tier high.

b. Drums are protected from direct rays of sun.

c. Maximum storage life of 2 years, unless storage life tests indicate product continues to meet purchase specification. Such tests are to be repeated at 1 year intervals thereafter.

Table 7-2. Hazard Group I.

Weight of Propellant in Pounds		Distance in feet	
		To inhabited buildings, public traffic routes, and incompatible group I storage	To intragroup and compatible group I storage**
Over Column 1	Not Over Column 2	Column 3	Column 4
0	100*	30	25
100	200*	35	30
200	300*	40	35
300	400*	45	35
400	500*	50	40
500	600	50	40
600	700	55	40
700	800	55	45
800	900	60	45
900	1,000	60	45
1,000	2,000	65	50
2,000	3,000	70	55
3,000	4,000	75	55
4,000	5,000	80	60
5,000	6,000	80	60
6,000	7,000	85	65
7,000	8,000	85	65
8,000	9,000	90	70
9,000	10,000	90	70
10,000	15,000	95	75
15,000	20,000	100	80
20,000	25,000	105	80
25,000	30,000	110	85
30,000	35,000	110	85
35,000	40,000	115	85
40,000	45,000	120	90
45,000	50,000	120	90
50,000	60,000	125	95

*A single standard minimum size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc., may be handled or stored without regard to distances prescribed.

**See paragraphs G. and H., above.

Table 7-2. Hazard Group I. (continued)

Weight of Propellant in Pounds		Distance in feet	
		To inhabited buildings, public traffic routes, and incompatible group I storage	To intragroup and compatible group I storage**
Over	Not Over		
Column 1	Column 2	Column 3	Column 4
60,000	70,000	130	95
70,000	80,000	130	100
80,000	90,000	135	100
90,000	100,000	135	105
100,000	125,000	140	110
125,000	150,000	145	110
150,000	175,000	150	115
175,000	200,000	155	115
200,000	250,000	160	120
250,000	300,000	165	125
300,000	350,000	170	130
350,000	400,000	175	130
400,000	450,000	180	135
450,000	500,000	180	135
500,000	600,000	185	140
600,000	700,000	190	145
700,000	800,000	195	150
800,000	900,000	200	150
900,000	1,000,000	205	155
1,000,000	2,000,000	235	175
2,000,000	3,000,000	255	190
3,000,000	4,000,000	265	200
4,000,000	5,000,000	275	210
5,000,000	6,000,000	285	215
6,000,000	7,000,000	295	220
7,000,000	8,000,000	300	225
8,000,000	9,000,000	305	230
9,000,000	10,000,000	310	235

**See paragraphs G. and H., above.

Table 7-3. Hazard Group II.

Weight of Propellant in Pounds		Distance in feet	
		To inhabited buildings, public traffic routes, and incompatible group II storage	To intragroup and compatible group II storage**
Over Column 1	Not Over Column 2	Column 3	Column 4
	100*	60	30
100	200*	75	35
200	300*	85	40
300	400*	90	45
400	500*	100	50
500	600	100	50
600	700	105	55
700	800	110	55
800	900	115	60
900	1,000	120	60
1,000	2,000	130	65
2,000	3,000	145	70
3,000	4,000	150	75
4,000	5,000	160	80
5,000	6,000	165	80
6,000	7,000	170	85
7,000	8,000	175	85
8,000	9,000	175	90
9,000	10,000	180	90
10,000	15,000	195	95
15,000	20,000	205	100
20,000	25,000	215	105
25,000	30,000	220	110
30,000	35,000	225	110
35,000	40,000	230	115
40,000	45,000	235	120
45,000	50,000	240	120
50,000	60,000	250	125
60,000	70,000	255	130
70,000	80,000	260	130
80,000	90,000	265	135
90,000	100,000	270	135

*A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc. may be handled or stored without regard to distances prescribed.

**See paragraphs G. and H., above.

Table 7-3. Hazard Group II. (continued)

Weight of Propellant in Pounds		Distance in feet	
		To inhabited buildings, public traffic routes, and incompatible group I storage	To intragroup and compatible group I storage**
Over	Not Over		
Column 1	Column 2	Column 3	Column 4
100,000	125,000	285	140
125,000	150,000	295	145
150,000	175,000	305	150
175,000	200,000	310	155
200,000	250,000	320	160
250,000	300,000	330	165
300,000	350,000	340	170
350,000	400,000	350	175
400,000	450,000	355	180
450,000	500,000	360	180
500,000	600,000	375	185
600,000	700,000	385	190
700,000	800,000	395	195
800,000	900,000	405	200
900,000	1,000,000	410	205
1,000,000	2,000,000	470	235
2,000,000	3,000,000	505	255
3,000,000	4,000,000	535	265
4,000,000	5,000,000	555	275
5,000,000	6,000,000	570	285
6,000,000	7,000,000	585	295
7,000,000	8,000,000	600	300
8,000,000	9,000,000	610	305
9,000,000	10,000,000	620	310

**See paragraphs G. and H., above.

Table 7-4. Hazard Group III.

Weight of Propellant in pounds		Distance in feet		
		To inhabited buildings, public traffic routes, and incompatible group III storage		To Intragroup and compatible group III storage**
Over	Not Over	Unprotected	Protected	
Column 1	Column 2	Column 3	Column 4	Column 5
0	100*	600	80	30
100	200*	600	100	35
200	300*	600	110	40
300	400*	600	120	45
400	500*	600	130	50
500	600	600	135	50
600	700	600	140	55
700	800	600	145	55
800	900	600	150	60
900	1,000	600	150	60
1,000	2,000	600	175	65
2,000	3,000	600	190	70
3,000	4,000	600	200	75
4,000	5,000	600	210	80
5,000	6,000	600	220	80
6,000	7,000	600	225	85
7,000	8,000	600	230	85
8,000	9,000	600	235	90
9,000	10,000	600	240	90
10,000	15,000	1,200	260	95
15,000	20,000	1,200	275	100
20,000	25,000	1,200	285	105
25,000	30,000	1,200	295	110
30,000	35,000	1,200	300	110
35,000	40,000	1,200	310	115
40,000	45,000	1,200	315	120
45,000	50,000	1,200	320	120
50,000	60,000	1,200	330	125
60,000	70,000	1,200	340	130
70,000	80,000	1,200	350	130
80,000	90,000	1,200	360	135
90,000	100,000	1,200	365	135

*A single standard minimum-size shipping container such as one 55-gallon drum, one 500-pound (net weight) cylinder, etc. may be handled or stored without regard to distances prescribed.

**See paragraphs G. and H., above.

Table 7-4. Hazard Group III. (continued)

Weight of Propellant in pounds		Distance in feet		
		To inhabited buildings, public traffic routes, and imcompatible group III storage		To Intragroup and compatible group III storage**
Over	Not Over	Unprotected	Protected	
Column 1	Column 2	Column 3	Column 4	Column 5
100,000	125,000	1,800	380	140
125,000	150,000	1,800	395	145
150,000	175,000	1,800	405	150
175,000	200,000	1,800	415	155
200,000	250,000	1,800	425	160
250,000	300,000	1,800	440	165
300,000	350,000	1,800	455	170
350,000	400,000	1,800	465	175
400,000	450,000	1,800	475	180
450,000	500,000	1,800	485	180
500,000	600,000	1,800	500	185
600,000	700,000	1,800	515	190
700,000	800,000	1,800	530	195
800,000	900,000	1,800	540	200
900,000	1,000,000	1,800	550	205
1,000,000	2,000,000	1,800	630	235
2,000,000	3,000,000	1,800	675	255
3,000,000	4,000,000	1,800	710	265
4,000,000	5,000,000	1,800	740	275
5,000,000	6,000,000	1,800	760	285
6,000,000	7,000,000	1,800	780	295
7,000,000	8,000,000	1,800	800	300
8,000,000	9,000,000	1,800	815	305
9,000,000	10,000,000	1,800	830	310

**See paragraphs G. and H., above.

Propellant Combinations	Static Test Stands	Range Launch Pade
LO_2/LH_2 or B_5H_9 + an oxidizer	60%	60%
LO_2/LH_2 + LO_2/RP-1	Sum of (60% for LO_2/LH_2)+ (10% for LO_2/RP-1)	Sum of (60% for LO_2/LH_2)+ (20% for LO_2/RP-1)
LO_2/RP-1 or LO_2/NH_3 or B_5H_9 + a fuel	10%	20% up to 500,000 pounds plus 10% over 500,000 pounds.
IRFNA/Aniline[1]	10%	10%
IRFNA/UDMH[1]	10%	10%
IRFNA/UDMH + JP-4[1]	10%	10%
N_2O_4/UDMH + N_2H_4[1]	5%	10%
N_2O_4/UDMH + N_2H_4[1] + solid propellants	5% plus the explosive equivalent of the solid propellants.	10% plus the explosive equivalent of the solid propellant.
Tetranitromethane (alone or in combination)	100%	100%
Nitromethane (alone or in combination)	100%	100%

Table 7-5. Liquid Propellant Explosives Equivalents.
(See footnotes, below)

[1]These are hypergolic combinations.

[2]The percentage factors given in the table are to be used to determine equivalencies of propellant mixtures at static test stands and range launch pads when such propellants are located above-ground and are unconfined except for their tankage. Other configurations shall be considered on an individual basis to determine equivalencies.

[3]The explosives equivalent weight calculated by the use of this table shall be added to any nonnuclear explosive weight aboard before distances can be determined from tables 7-4 and 7-5.

[4]These equivalencies apply also for the following substitutions:

a. Alcohols or other hydrocarbons for RP-1.

b. BrF_5, ClF_3, F_2, H_2, H_2O_2, OF_2, or O_2F_2 for LO_2.

c. MMH for N_2H_4 or UDMH.

d. C_2H_4O for any propellant.

e. NH_3 for any fuel resulting in a hypergolic combination.

[5]Use LO_2/RP-1 distance for pentaborane plus a fuel and LO_2/LH_2 distances for pentaborane plus an oxidizer.

[6]For quantities of propellant up to but not over the equivalent of 100 pounds of explosives, the distance shall be determined on an individual basis by the PCO. All personnel and facilities, whether involved in the operation or not, shall be protected by operating procedures, equipment design, shielding, barricading, or other suitable means.

[7]Distance less than intraline area not specified. Where a number of prepackaged liquid propellant units are stored together, separation distance to other storage facilities shall be determined on an individual basis by the PCO, taking into consideration normal hazard classification procedures.

Table 7-5. Liquid Propellant Explosives Equivalents. (continued)

Table 7-6. Distances for Separation of Propellant Static Testing, Launching, and Storage Sites from Other Facilities.

Weight of explosives or group IV propellant in pounds	Distance in feet from propellant explosive hazard			
	To inhabited buildings	To public traffic routes	Intraline	
Column 1	Column 2	Column 3	Column 4	Column 5
Not Over			Barricaded	Unbarricaded
100	190	115	40	80
200	235	140	50	100
300	270	160	60	120
400	295	175	65	130
500	320	190	70	140
600	340	205	75	150
700	355	215	80	160
800	375	225	85	170
900	390	235	90	180
1,000	400	240	95	190
1,500	460	275	105	210
2,000	505	305	115	230
3,000	580	350	130	260
4,000	635	380	140	280
5,000	685	410	150	300
6,000	730	440	160	320
7,000	770	460	170	340
8,000	800	480	180	360
9,000	835	500	190	380
10,000	865	520	200	400
15,000	990	595	225	450
20,000	1,090	655	245	490
25,000	1,170	700	265	530
30,000	1,245	745	280	560
35,000	1,310	785	295	590
40,000	1,370	820	310	620
45,000	1,425	855	320	640
50,000	1,475	885	330	660
55,000	1,520	910	340	680
60,000	1,565	940	350	700
65,000	1,610	965	360	720
70,000	1,650	990	370	740
75,000	1,685	1,010	385	770
80,000	1,725	1,035	390	780
85,000	1,760	1,055	395	790
90,000	1,795	1,075	400	800
95,000	1,825	1,095	410	820
100,000	1,855	1,115	415	830
125,000	2,115	1,270	450	900
150,000	2,350	1,410	475	950
175,000	2,565	1,540	500	1,000

Table 7-6. Distances for Separation of Propellant Static Testing, Launching, and Storage Sites from Other Facilities. (continued)

Weight of explosives or group IV propellant in pounds	Distance in feet from propellant explosive hazard			
	To inhabited buildings	To public Traffic routes	Intraline	
Column 1	Column 2	Column 3	Column 4	Column 5
Not Over			Barricaded	Unbarricaded
200,000	2,770	1,660	525	1,050
225,000	2,965	1,780	550	1,100
250,000	3,150	1,890	575	1,150
275,000	3,250	1,950	585	1,170
300,000	3,345	2,005	600	1,200
325,000	3,440	2,065	620	1,240
350,000	3,525	2,115	635	1,270
375,000	3,605	2,165	650	1,300
400,000	3,685	2,210	665	1,330
500,000	3,970	2,380	715	1,430
600,000	4,215	2,530	780	1,560
700,000	4,440	2,665	825	1,650
800,000	4,640	2,785	860	1,720
900,000	4,825	2,895	895	1,790
1,000,000	5,000	3,000	925	1,850
1,500,000	5,725	3,435	1,060	2,120
2,000,000	6,300	3,780	1,170	2,340
2,500,000	6,785	4,070	1,260	2,520
3,000,000	7,210	4,325	1,340	2.680
3,500,000	7,590	4,555	1,405	2,810
4,000,000	7,935	4,760	1,470	2,940
5,000,000	8,550	5,130	1,585	3,170

Table 7-7. Factors To Be Used When Converting Gallons of Propellant into Pounds.[1]

Item	Pounds/gallon	At temperature °F
Anydrous Ammonia	5.1	68
Aniline	8.5	68
Bromine Pentafluoride	20.7	68
Chlorine Trifluoride	15.3	68
Ethyl Alcohol	6.6	68
Ethylene Oxide	7.3	68
Fluorine (Liquid)	12.6	-306
Furfuryl Alcohol	9.4	68
Hydrocarbon Fuel JP-4	6.35	60
Hydrocarbon Fuel JP-5	6.84	60
Hydrogen Peroxide (90%)	11.6	68
Hydrazine	8.4	68
Isopropyl Alcohol	6.6	68
Liquid Hydrogen	0.59	-423
Liquid Oxygen	9.5	-297
Methyl Alcohol	6.6	68
Mono Methyl Hydrazine	7.3	68
Monopropellant NOS-58-6	9.46	68
Nitromethane	9.5	68
Nitrogen Tetroxide	12.1	68
Oxygen Difluoride	12.7	-229
Ozone Difluoride	14.6	-297
Pentaborane	5.2	68
Perchloryl Fluoride	12.0	68
Red Fuming Nitric Acid (III A)	12.5	68
RP-1	6.8	68
Tetranitromethane	13.6	78
Triethyl Boron B	5.8	73
UDMH	6.6	68
UDMH/Hydrazine	7.5	68

[1]Conversion of quantities of propellant from gallons to pounds:
Pounds of propellant = gallons X density of propellant in pounds per gallon.

CHAPTER 8

MANUFACTURING AND PROCESSING PYROTECHNICS

A. GENERAL

The safety precautions for manufacturing and processing pyrotechnics parallel those of many types of explosives and other energetic materials. Pyrotechnics, as a group, display many different characteristics because they are formulated for different purposes. Pyrotechnics can be divided into general categories, such as: initiators (igniters); illuminants; smokes; gas generators; sound generators; heat producers; and timing compositions. Each has its own characteristics and attendant processing requirements. Knowledge of these characteristics is necessary to ensure safety in processing. The range of characteristics associated with pyrotechnics includes easily initiated compositions from those that burn in seconds at temperatures exceeding 2763°C (5000°F) through those that require substantial energy for initiation and have relatively low output temperatures. As examples, the auto-ignition temperature for smoke compositions is typically about 180°C while for illuminants it is about 500°C; illuminants burn approximately 2.7 times faster than smokes and the heat of reaction is 1.5 times as great; infrared (IR) flare compositions are both hotter and faster-burning than illuminants. Many of the compositions in the ignitor or initiator class are as sensitive to static electricity, friction, or impact as are initiating explosives such as lead azide and lead styphnate. Initiation thresholds to such stimuli as impact, friction, and electrostatic discharge must be known for safety in specific processes. The response of the material in terms of energy release must be considered in ensuring personnel safety. In addition to the safety precautions generally required for the handling of explosives and other energetic materials, the following paragraphs provide specific guidance pertinent to pyrotechnic operations.

B. MACHINERY, EQUIPMENT, AND FACILITIES

Except as provided for in this chapter, the design, layout, and operation of facilities and equipment will follow the mandatory provisions for the processing of explosives and other energetic materials contained elsewhere in this Manual. Where guidance is not provided, operations should be governed by the results of hazard analyses performed and documented to address specific operations. As most pyrotechnic compositions are sensitive to initiation by static electricity, bonding and grounding, along with other means of static elimination and control, have paramount importance.

C. WEIGHING OF RAW MATERIALS

Separate weight or measurement rooms, cubicles, or areas (dependent upon the quantity and sensitivity of the materials handled) will be provided -- one for oxidizers and one for combustible materials and metallic powders. It is important that containers, equipment, hand tools, scale pans, etc., used for weighing processes are not mixed with those weighing or measuring oxidizers and fuels, particularly where distance rather than physical barriers separates these areas. Positive measures will be adopted to ensure the complete separation of such equipment and tools. Personnel weighing or handling exposed oxidizers or fuels shall, at a minimum, wear flame retardant uniforms, cotton undergarments, cotton socks, and conductive shoes.

D. DRYING OF MATERIALS

The minimum temperature necessary to meet processing requirements will be used to dry components and pyrotechnic materials. Drying rooms or ovens must meet the requirements of Chapter 13, paragraph F.

E. MIXING AND BLENDING

Mixing and blending of pyrotechnic compositions commands attention because most injury-producing accidents have occurred during the mixing, blending, or subsequent cleanup operations. Because of the variety within and among these compositions, no single type of mixer or blender can be the exclusively approved equipment for pyrotechnic mixing and blending operations.

1. Each mixing device must be considered separately with respect to the composition to be processed. When a history of safe operation has not been established, the type of mixer or blender and batch size should be evaluated by appropriate hazard analysis or tests. Generally, devices that use a tumbling action will be preferred to those using rotating blades, to minimize points where frictional heat may develop or where accidentally introduced foreign material can create hot spots through friction or crushing of composition. Mixers and blenders will be equipped for pressure relief, to preclude a transition from burning to detonation. Personnel exposures during charging and emptying of mixers will be minimal. When the energetic characteristics and quantities of composition involved so dictate, mixers and blenders will be charged, operated, and emptied remotely. When hazard analysis or testing has shown this to be safe, mixers or blenders may be charged or emptied manually. Appropriate interlocks, clutch brakes, and similar devices will be used to preclude personnel exposure during mixer or blender operation, and to preclude the movement of mixer or blender parts during periods when operators are present.

2. Mixing and blending operations will be conducted in buildings or cubicles designed for such purposes. Multiple mixing or blending operations may be conducted in the same building, provided that each blender or mixer is located in a separate room, bay, or cell, and separated from other operations by substantial dividing walls. Two or more mixers or blenders may be located in the same cubicle, provided that the hazards are not increased by such installation. Normally, this would require that the materials in process be of significantly low energy content or slow energy release and the mixers be charged and emptied simultaneously. At least one wall or equivalent panel area in each bay shall be frangible so as to provide pressure relief in the event of an incident. Cell arrangement and pressure relief areas shall be located so that personnel can not pass in front of these areas while mixers or blenders are operating.

3. Exhaust ventilation equipment will be installed on mixers or in bays where flammable solvents are used and interlocked with the mixers. The interlock shall be designed to preclude mixer operation without ventilation although operation of the ventilation system without the mixer is permitted. Vapor sensors should be used to give automatic warning of a build-up of flammable vapors to a level approaching that of the lower explosive limit. Such sensors should be interlocked to personnel access control devices. Ventilation system designs must not permit propagation of an incident in one bay to others served by the same system.

4. The operation of mixers or blenders may be observed by remote means such as closed-circuit television, mirrors, or transparent shields providing operator protection. Direct viewing of blender or mixer operation without intervening barriers is prohibited.

5. Manual scraping during the mixing or blending process is prohibited. Manual mixing or blending of fuels and oxidizers is prohibited.

F. PRESSING, EXTRUDING, AND PELLETING

1. Pressing operations will be conducted with personnel protected by substantial dividing walls, barricades, or operational shields; or will take place at intraline distance from the operator and other operations. When it is necessary to repair, adjust, or otherwise clear a jam on a press or extruder, the pyrotechnic material will be removed from the hopper and the bay or press room before such repairs or adjustments are made. Only those adjustments of ram speed or conveyor speed routinely controlled by the operator may proceed with material in the bay. Under no circumstances shall repair or adjustment requiring the use of tools be permitted with pyrotechnic material in the bay.

2. The quantity of composition at the pressing location (behind the barricade) will not exceed that required for the components undergoing the pressing operation. The quantity of composition in the remainder of the building at any one time will not exceed the minimum required for a safe, efficient operation.

3. Each individual press, extruder, or loading device shall be located in a separate building, room, or cubicle, and be designed to limit an incident to that area and protect operators. Multiple installations may be permitted within a bay or cubicle, provided that tests or hazard analysis demonstrate that facility and personnel hazards are not increased. Adequate means of pressure relief will be built into each bay or cubicle.

G. ASSEMBLY OPERATIONS

Individual assembly operations shall be adequately separated from each other, and shall be located in a separate cubicle or building from mixing, blending, and consolidation operations. Pyrotechnic composition will be kept in closed or covered containers at all times except during processing. Surge, storage, and in-process transit between operations will also be accomplished with closed containers whenever not absolutely prohibited by the operational configuration. Components in any assembly room, bay, or building will be limited to the smallest quantity necessary for safe and efficient operations.

H. GRANULATION, GRINDING, AND SCREENING

1. Material to be reduced in particle size will be processed over a mechanical or magnetic separator to remove foreign materials before grinding. Following grinding, the material should be rescreened or passed over a magnetic separator.

2. In the operation of ball mills, hammer mills, granulators, or screeners, the operator shall be protected from the effects of a potential incident by substantial dividing walls or operational shields. Every effort will be made

to fill and discharge grinding, granulating, and screening equipment remotely. Cleaning of such devices will also afford maximal operator protection.

3. Working surfaces, containers, and hand tools will be appropriately bonded and grounded.

I. TRANSPORTATION

Pyrotechnic compositions will be moved in closed containers only. Individual containers and the transport vehicle (hand cart, hand truck, etc.) should be fabricated of the lightest materials compatible with the composition and having the requisite strength. This will minimize fragment generation if an incident should occur. Transport vehicles should be equipped with "dead man" brakes. On- and off-loading of transport vehicles should be conducted only in weather-protected areas designated for this purpose. Racks or other support, suited to the size and shape of composition containers, should be provided to prevent them from falling.

J. REBOWLING

Rebowling operations transfer materials, typically sensitive and in small quantities, from one container to another. They may be done to recover remains of small quantities of materials, or to subdivide large masses for processing. Operational shields will be provided to protect operators.

K. MACHINING OF PYROTECHNIC MATERIAL

1. Machining of pyrotechnic materials will be accomplished remotely.

2. General Requirements

a. When required, coolant must be compatible with the pyrotechnic composition. Positive automatic interlocking devices will ensure that the machine cannot be started until the coolant is flowing. These controls must also be capable of stopping the machine should the flow of coolant be interrupted. When it is essential to cut off the coolant to adjust machine tools, it must be restored, and all automatic controls operating, before machining resumes. If a cutting edge overheats during machining, it is most dangerous when continuous contact with the pyrotechnic material is maintained after the machine has stopped. It is, therefore, essential that coolant continue flowing until the cutter is removed from contact with the pyrotechnic material.

b. Sensors are recommended to detect tooling malfunctions or other potentially hazardous conditions. Machine tool power-consumption monitors, tool force gages, sound or noise detectors, temperature-indicating devices, or IR detectors can be utilized in this regard.

c. Cutting tools must be chemically compatible with the pyrotechnic material to be machined, capable of maintaining a sharp cutting edge throughout the machine cycle.

d. Control measures such as guides, bushings, and stops must limit depth, diameter, and contour of the cut. The lineal and rotational speed of tools for the machining of pyrotechnic material will be the minimum necessary

for safe and efficient operation. Controls should be designed to prevent unintended operator adjustment.

e. Drilling operations must not impede the flow of chips and coolant in the bore. The drilling of small holes (one-quarter inch or less) and any size of multiple drilling operation will be performed by remote control, with operator protection, unless documented hazard analysis or tests prove this unnecessary.

f. Contoured cutting tools must be removed from contact with the pyrotechnic material being machined before personnel are permitted to enter the machining area. Frequently cleaning machine tools during operating hours will prevent residues from accumulating; a through cleaning will conclude each work shift. Vacuum accumulator systems, immersion in liquid coolant streams, or similar automatic means will remove the pyrotechnic waste products. Only low pressure (10 PSIG) compressed air may be used as a coolant and only when the scattering of pyrotechnic particles is contained by a vacuum collection system. The coolant delivery tube shall have a metallic tip or nozzle grounded to the machine to reduce static charges.

3. Specific Guidance for Machining

a. Drilling and facing operations for colored smoke compositions containing organic dyes, potassium chlorates, and sugars should be conducted at not more than 2475 lineal inches per minute, with the feed rate adjusted to enhance the machinability of the composition. For red phosphorous compositions, drilling and facing operations should be conducted at not more than 1100 lineal inches per minute with the feed adjusted to minimize friction and heat buildup. For extruded candles composed of magnesium, tetrafluoroethylene polymers, and fluoroelastomer binders, drilling and machining operations shall be conducted at not more than 530 lineal inches per minute.

b. Hand trimming and cutting of pyrotechnic candles may be permitted when supported by results of a hazard analysis specific to that composition and candle configuration.

c. Sawing operations require particular care, to prevent work from plunging into the saw blade and to ensure that chips are removed from saw teeth before their next cutting pass. Plunging can occur when thin sections are force-fed into coarse-pitch saw blades. To prevent this, a minimum of two saw teeth must remain in contact with the work during sawing, or the work feed must be controlled. Chip accumulation in saw teeth is a function of the material being sawed, rate of feed, blade speed, tooth design, and flushing arrangement. Additional chip removal equipment such as blade-wiping brushes may be required.

L. SPILL CONTROL

Spills of pyrotechnic composition and energetic ingredients pose potential hazards. In case of accident, the responsible supervisor should be notified before any action to clean or contain the spill. SOP for pyrotechnic operations will cover spill cleanup, either as part of the various operations detailed or as a separate procedure. The procedures shall specify which actions are to be taken by whom and in what order. The recovery of the spilled material and decontamination of the area will also will also be addressed.

M. COLLECTION OF PYROTECHNIC WASTES

1. Waste material and scraps will be removed at regular intervals from all operating areas. All waste material will be segregated by type and compatibility, and kept separate from common wastes. Containers for these materials shall be distinguished by color, and labeled. Filled containers shall be placed at designated collection points.

2. Special care will preclude the mixing of small quantities of water with powdered or finely granulated metals. Pyrotechnic waste may be maintained dry or submerged in water or oil, whichever is appropriate for disposal. Plastic liners for waste containers facilitate cleaning. Liners should be conductive when contents are subject to initiation by static electrical discharge.

N. CLEANING OF PYROTECHNIC PROCESSING EQUIPMENT

1. As pyrotechnic materials are sensitive to friction, impact, or static discharge, cleaning this equipment poses hazards. Because personnel must be near the equipment being cleaned, risks may exceed those of processing. Therefore, cleaning will receive the same planning and SOP coverage as production.

2. Solvent solution flushing and cleaning by remote control is required for slurry-type mixing operations. For other applications, the process equipment will be flushed with a compatible solvent and drained, with the process repeated as often as necessary to remove the pyrotechnic composition. High-pressure water wash may be used when compatible with the pyrotechnic composition. Precautionary measures will be taken when a solvent represents a fire or toxicological threat. Runoff from cleaning operations will be controlled to preclude the creation of a secondary hazard from the spread of contamination.

3. When remote cleaning cannot be used, personnel protective equipment will be designed and proven by test to afford operator protection from the maximum quantity of material that could be present, and its use will be required.

O. PERSONAL PROTECTIVE EQUIPMENT

1. Personal protective equipment will not be relied upon as the primary means of operator protection. The primary means should be by reducing the quantities being handled to the minimum necessary by using operational shields. Supplemental operator protection should be afforded by high speed deluge systems designed and installed for such purposes. The personal protective apparel prescribed in an SOP will be based upon the hazards associated with the operation.

2. The minimum protective apparel for personnel exposed to open containers of pyrotechnic or energetic raw materials will consist of the following:

a. Cotton undergarments and socks.
b. Conductive-soled safety shoes.
c. Flame retardant coveralls.
d. Hair coverings.

3. All employees exposed to hazardous quantities of pyrotechnic compositions will wear the additional items described below. The definition of hazardous quantities will depend on the composition's energy output and sensitivity (as determined by hazard analysis or tests) and the nature of the operation. Required levels of protective apparel will be specified in appropriate SOP steps.

a. Aluminized, thermally protective suit with hood and face plate.
b. Aluminized, thermally protective trousers.
c. Aluminized, thermally protective gloves or equivalent.

4. When the items described above are required, the design and wearing will ensure that no areas of the body are exposed. Appropriate seals or joints will be used to preclude flame intrusion where apparel items overlap or are joined. Particular attention will be given to possible gaps in coverage provided by the hood in order to prevent flame or hot gas impingement on the face, head, or neck.

P. ADDITIONAL CONTROLS

1. Many materials used to produce pyrotechnics are toxic, represent fire hazards, or both. Operations will provide protection from these threats. Vapor- and dust-removal and collection systems must be provided where toxic or flammable dusts or gases are generated. Design and installation of such equipment must meet environmental as well as safety standards.

2. Blankets should be provided in easily opened containers within 25 feet of operations where they could be required for wrapping burned employees. Alternate means of achieving the same effect should be provided when blankets are not.

3. When required, conductive shoes will be checked for conductivity daily before the beginning of work. A permanent log of the testing should be maintained.

4. Relative humidity shall be maintained in locations where pyrotechnic materials are processed, to minimize the hazard of static electricity while controlling condensation.

Q. REWORKING PYROTECHNIC COMPONENTS

1. All repair, reassembly, or similar operations on loaded pyrotechnic compositions will take place in a separate bay used only for that purpose.

2. Consolidated or extruded pyrotechnic compositions will normally be destroyed, not pulverized for reblending. While HC smoke and such compositions are reusable, more sensitive materials, such as IR flare compositions, are not.

R. FIRE PROTECTION

When compatible with process materials, deluge systems may be used for the protection of mixing and blending operations, screening, granulation, drying, and pressing or extrusion operations. The response time of the deluge system should be selected to minimize the damage to process equipment and facilities. Hazard analysis of the operation may dictate other applications.

CHAPTER 9

STORAGE OF EXPLOSIVES AND AMMUNITION

A. GENERAL

A properly sited segregated and separate storage area is preferred for explosives storage. Earth-covered magazines (igloo or other subsurface) offer the greatest protection to explosives. Such magazines are preferred for the storage of all explosives. Earth-covered magazines provide protection from weather and fire, and relatively constant temperature control.

B. STORAGE CONSIDERATIONS

Factors to consider when designating a structure for explosive storage are:

1. Magazine construction and location.

2. Quantity of explosives to be stored (see table 6-4 for Q/D criteria for class/division 1.1 explosives; table 5-1 for compatibility).

C. MAGAZINE OPERATIONAL REGULATIONS

1. No loose ammunition components, packing materials, conveyors, skids, dunnage, empty boxes, or other such items will be stored in magazines containing ammunition or explosives.

2. No crew shall work in a spot that requires passing a second crew's work aisle or position to reach an exit in a magazine. The numbers of crews should not exceed the number of exits. Doors must remain unlocked and permit rapid egress.

3. Flammable liquids, except when used as the chemical filler of a munition, or as a prepackaged storable liquid propellant, will not be stored in magazines containing explosives.

D. STACKING

1. Ammunition and explosives should be stored in original shipping containers or equivalent. Explosives or ammunition in stacks should be grouped and identified according to lots. General rules set forth in paragraphs D.2. and D.3., below, shall be followed in the absence of applicable storage drawings.

2. Methods used for stacking must provide for good ventilation to all parts of the stack. Adequate dunnage shall be used for this purpose.

3. Aisles shall be maintained so that units in each stack may be inspected, inventoried, and removed for shipment or surveillance tests. Block storage is permitted, provided adequate ventilation of stacks exists. Unobstructed aisles shall be maintained to permit rapid egress.

4. Only one light box, pallet, or unit should be allowed per lot in storage. Stacked light units should be readily visible and immediately accessible.

E. LOOSE ROUNDS, DAMAGED CONTAINERS

Loose rounds of ammunition, or single fiber containers with rounds therein, will not be stored in magazines containing ammunition items packed in original shipping containers; however, they may be stored in magazines set aside for their exclusive storage. Incomplete boxes of ammunition and explosives may be stored in magazines containing complete boxes packed in original shipping containers. Conspicuously marked to identify contents and quantities, the incomplete boxes must be placed in designated locations. Explosives and ammunition in damaged containers should not be stored in a magazine with ammunition in serviceable containers. Such containers should be repaired or the contents transferred to new or serviceable containers. Open containers and containers with covers not securely fastened must not be allowed in magazines. Containers that have been opened shall be properly closed before being re-stored. Stored containers should be free from loose dust and grit.

F. REPAIRS TO MAGAZINES

1. Repairs should not be made to the interiors of magazines containing bulk explosives. Repairs to roofs, ventilators, lightning rods, doors and other parts of, or appendages to, the exteriors of magazines containing bulk explosives will not normally require removing the explosives. Minor repairs may be made to the interiors of magazines containing finished ammunition or ammunition components.

2. The general safety requirements set forth in this Manual, particularly the elimination of fire hazards, shall be followed when magazines are repaired. When necessary, baffles and screens should be used to confine sparks and flames to heating apparatus.

G. OPEN STORAGE (OUTDOORS)

Open storage of A&E is prohibited.

H. STORAGE OF BULK INITIATING EXPLOSIVES

Bulk initiating explosives must not be stored dry nor exposed to the direct rays of the sun. Containers of ample size to hold the double bag of explosives are used for normal storage. Covers designed and constructed to prevent friction and pinch points should be used. Covers of shipping containers used for long-term storage must be equipped with a port for observing the level of the liquid contents. The viewing port must have a transparent plastic cover proven compatible with the initiating explosives being stored. Bulk initiating explosives may, for expediency, be stored in shipping containers without viewing ports, provided they are stored in magazines that will prevent freezing; with containers on end, only one tier high; with passageways for inspection and handling. Bags of initiating explosives in storage containers must be under distilled water. Alcohol may be added to the distilled water to prevent freezing.

I. ROCKETS AND ROCKET MOTORS

1. In above-ground magazines, rockets and rocket motor items (in a propulsive state) should be pointed in the direction least exposing personnel and property in case of fire or explosion.

2. Rockets should be stored in dry, cool magazines, out of the direct rays of the sun. Prolonged exposure of rocket ammunition to either high or low temperatures may increase the normal rate of deterioration or render the motors more susceptible to ignition if handled improperly later.

CHAPTER 10

FIRE PROTECTION

A. GENERAL

This chapter provides general standards for personnel developing and effecting fire protection and prevention programs in A&E environments.

B. FIRE PLAN

A written fire plan shall be prepared. Although details may vary, plans for all establishments shall itemize the emergency functions of each department or outside agency, indicating responsible individuals and alternates.

C. FIREFIGHTING AGREEMENTS

Voluntary and mutual agreements with nearby municipalities or industrial centers should include firefighting procedures as established by the plant officials. Plant officials are responsible for informing the assisting firefighters of particular procedures to be followed. Outside firefighters should not assist in fires involving A&E. If the practical need for their doing so can be anticipated, th shall receive advance instruction in A&E firefighting procedures. Outside firefighters shall never attack fires involving hazard classes 1.1 and 1.

D. SMOKING

Smoking may take place only in safe, specifically designated and posted "smoking locations."

1. Cigarettes, tobacco, and matches shall be discarded in ash receptacles only. They shall not be dropped into trash cans.

2. Electric lighters with automatic pressure cutoffs shall be fixed, ensuring against removal.

3. At least one fire extinguisher shall be provided at smoking locations.

4. Persons wearing clothing contaminated with explosives or other dangerous material should not be permitted in smoking areas.

E. PERMITS

A written permit shall be required for the temporary use of heat-producing equipment or devices when explosives or highly flammable materials are involved.

F. PORTABLE FIRE EXTINGUISHERS

Hand extinguishers within buildings can squelch incipient fires before major damage is done. Portable equipment may prove similarly valuable outside aboveground magazines and other buildings with explosives.

C. HAZARDS IN FIGHTING FIRES INVOLVING AMMUNITION AND EXPLOSIVES

A fire hazard identification system must be adopted. This shall assess relative dangers, up to the most hazardous material stored.

1. The following fire symbol system is provided as a guide:

a. Fire divisions, numbered "1" through "4," shall correspond to hazard classes 1.1 through 1.4.

b. The lower the number, the greater the hazard:

Fire Division	Hazard Involved
1	Mass detonation
2	Explosion with fragment hazard
3	Mass fire
4	Moderate fire

c. Distinctively shaped placards, instantly recognizable from a distance, signify the different divisions. Each placard, or symbol, shows the fire division number:

Shape	Fire Division
Octagon	1
Cross	2
Inverted triangle	3
Diamond	4

d. Black numbers appear on orange backgrounds as used by NATO, UNO, IMCO, and DOT. Reflectorized or luminous symbols are preferred.

2. Firefighting Procedures

a. General

(1) Fires should be immediately reported and fought without specific authorization. However, personnel should evacuate and seek safety if fires involve explosive materials, or cannot be controlled by equipment at hand. Training of operational personnel shall cover the characteristics of explosive materials, including their reactions to heat and fire, as well as what to do in case of fire.

(2) Firefighters should be thoroughly informed of the specific reactions of A&E exposed to heat or fire.

(3) Firefighters should be briefed on conditions at the scene before proceeding.

(4) Ammunition containing both explosives and chemicals (such as groups C and D) requires special precautionary measures. (See Chapter 11.)

b. Specific

(1) Personnel shall not attempt to fight fires involving A&E in hazard classes 1.1 and 1.2. Because this material detonates with a fragmentation hazard, personnel shall evacuate immediately, using protective cover and activating deluge systems and fire alarms while escaping. Individuals remain in danger until they reach shelters, although reaching inhabited building distances in the open affords some safety. During exit drills, employees shall be advised of the safest escape routes.

(2) If the fire in a 1.1 or 1.2 building involves nonexplosive material and is small or in a segregated container, an attempt may be made to extinguish the fire. After summoning firefighters, responsible parties should attempt to meet them as they approach, to brief them. When 1.1 or 1.2 materials are directly involved, firefighting forces should maintain inhabited building distance from the fire. The safety of personnel fighting a 1.1 or 1.2 fire depends on the accuracy of the information made available to all firefighting forces. No person shall reenter a burning building containing 1.1 or 1.2 materials.

(3) Personnel in the immediate vicinity of hazard class 1.3 explosives should activate deluge systems and alarms. Unless the fire is minor, involves no explosive, and appears controllable, the firefighting organization shall confine its efforts to preventing it from spreading to other buildings. Fire in these class 1.3 materials creates a wide area of intense radiant heat, dangerous to personnel and equipment. The firefighting organization should exercise extreme caution.

(4) Hazard class 1.4 A&E present a moderate fire hazard. Fires involving them shall be fought until extinguished.

H. AUTOMATIC SPRINKLER SYSTEMS

Properly installed and maintained automatic sprinklers reduce fire losses. They are particularly useful for load lines; explosives manufacturing; receiving, shipping, inspection, and ammunition workshops; and demilitarization.

I. CLEARANCE UNDER SPRINKLERS

At least 18 inches shall separate sprinkler deflectors from stored materials piled 15 feet high or less; in all other cases, the clearance shall be at least 36 inches. A minimum clearance of 36 inches shall be maintained between sprinkler and extremely hazardous materials, and between sprinklers and baled storage, regardless of height.

J. DELUGE SYSTEMS

1. Deluge systems should supplement sprinklers when the hazards are high, as in powder hoppers and cutters. Rate of rise, light-actuating, ultraviolet, or other quick-action devices for automatic control of deluge systems are recommended. Quick-acting manual controls should serve as backup.

2. To ensure immediate drenching of all parts of the machine, the distribution outlets (nozzles, sprays, heads, etc.) should be as near the explosive's exposed surface as permitted by the outlet discharge pattern. When explosives are under tight hoods or covers inside machines, distributing outlets belong inside the enclosed space.

3. Nonmetallic, internally spring-held caps should protect outlets exposed to explosive vapors, gases, or dust. Upon exertion of pressure within the outlet, the cap must pop immediately. Caps should be attached to outlets to prevent their dropping into equipment during a deluge.

4. Required water flow and pressure should be determined for the hazard.

5. Periodic inspections of deluge systems shall ensure that they are in proper operating condition.

6. The deluge valve should allow for automatic and manual activation. Manual activation devices shall be placed at exits in explosives-operating buildings. They may also be located at the operator stations when hazard analysis determines the risk to personnel acceptable.

7. NFPA Standards No. 13 and No. 15 (reference (i)) contain basic installation rules.

K. HAZARDS IN FIGHTING FIRES INVOLVING LIQUID PROPELLANTS

For safety's sake, firefighters must know the burning characteristics and specific hazards of liquid propellants. Burning liquid propellants' fumes are generally toxic, so firefighters should remain on the upwind side. Protective clothing should include an approved, self-contained breathing apparatus.

CHAPTER 11

SPECIFIC CHEMICALS

A. GENERAL

This section covers specific chemicals used during explosives manufacturing/processing and provides basic guidance for the establishment of local safety requirements. Publications listed below are acceptable as guides in the formulation of safety standards except where they conflict with the requirements of this Manual:

1. Chemical Data Sheets, National Safety Council.

2. Liquid Propellant Handling, Storage and Transportation, CPIA publication No. 194, dated 1970.

3. Patty's Industrial Hygiene and Toxicology.

4. Industrial Fire Hazards Handbook.

5. Dangerous Properties of Industrial Materials - Sax.

B. REPAIRS TO ACID EQUIPMENT

1. Before a pipeline, pump, or other equipment exposed to acid is dismantled for repairs, it should be drained and washed down with water. All pressure must be relieved; valves, switches, etc., must be tagged or locked to prevent the accidental application of pressure or the introduction of acid into the line. Branch lines where pockets may exist require particular attention. All pumping on the system connected with parts under repair should cease, with starters tagged and locked, unless blank flanges in the lines cut off the affected parts from the pump. In breaking a flange, the bottom bolts should be loosened first and the first line allowed to sag slightly, permitting the liquid to run out by gravity. Spilled liquid shall be disposed of properly after the repairs. Absent other information, chemical pipelines shall be assumed to contain liquid.

2. Repairing used-steel acid tanks presents two types of hazards. Even a trace of weak acid or weak acid sludge will violently react on the metal, generating gases. These could cause an explosion if welding is carried out on the tank. Personnel working inside the tank risk serious poisoning from the gases. Therefore, before repairs start, the tank shall be washed out, filled with water, then drained. If any acid remains, it may be necessary to apply soda ash solution and steam, then fill the tank with water, repeating the original procedure. When someone is working inside the tank, an observer shall be present, with at least one other person available for rescue work, should the worker in the tank be overcome; such personnel shall receive training in tank rescue work. Those entering tanks shall have respiratory protective equipment, life belts, or harnesses and lifelines.

3. Neutralizing Spills. Slaked (hydrated) lime shall be available to neutralize spilled acid. A 10 to 20 percent solution of sodium bicarbonate will remove acid from floors or equipment. Because neutralization generates

heat, care must be taken in cleaning large quantities of acid. Soda or other alkaline solutions shall neutralize all places made slippery by acid, which shall then be flushed with water.

4. Mixing Acid With Water. The acid shall be added to the water, never the water added to the acid, when significant amounts are being diluted. Acid should be added slowly with agitation. Weak acid replacing water as the diluting agent requires similar precautions. Solutions shall be thoroughly mixed, particularly in steel tanks.

5. Empty Containers. Carboys that have contained acids must be thoroughly drained before being offered for transportation. They will be shipped in the same manner as full items.

C. MIXED ACIDS

Mixed acids include mixtures of sulfuric and nitric acids used in the nitration of various explosives constituents. The pressure of liberated gases sometimes causes carboys of mixed acids to rupture violently. Mixed acids can start fires, generate gases that cause explosions, and emit poisonous oxides of nitrogen. Mixed acid containing not less than 10 percent of nitric acid will not freeze at ordinary temperatures and will not actively attack steel storage tanks.

D. WASTE ACIDS (SPENT ACIDS)

Waste acids usually contain small amounts of nitrobodies, so present the hazard of explosive material. Spent acid from the manufacture of nitroglycerin and liquid esters are particularly hazardous.

E. NITRIC ACID

Nitric acid forms explosive compounds with most organic materials. With most oxidizable material, it forms flammable compounds, some of which are subject to spontaneous ignition. Nitric acid fire creates exceedingly toxic oxides of nitrogen. Buildings where nitric acid is used must have proper ventilation. Enough space shall separate them to allow for firefighting forces; also, to prevent the accumulation of acid "fumes" (sometimes colorless, at other times identifiable, ranging from dark yellow to brown). The first symptoms of nitrous poisoning are usually followed by a latent period, when the victim feels comfortable though the poisoning continues. For this reason, anyone with even mild symptoms of nitrous poisoning must immediately be made completely still, attended by a physician as soon as possible.

F. SULFURIC ACID (OIL OF VITRIOL)

Concentrated sulfuric acid chars wood, cotton, and vegetable fibers, usually without causing fire, but oleum (fuming sulfuric acid) usually does cause fire in these materials. The addition of water may create heat sufficient to cause a fire or explosion, and greatly increases the corrosive properties of oleum. This does not preclude the use of large quantities of water to dilute or dissipate small quantities of acid. Sulfuric acid must not be stored with nitric acid, volatile or flammable liquids, or oxidizing agents. It may be

stored in carboys, drums, tanks, glass bottles, and in large outdoor tanks. All precautions listed for sulfuric acid apply to oleum. In an emergency, sand, earth, or other noncombustibles may be used to absorb oleum spilled or leaking from storage containers. Once the crisis has passed, the oleum-soaked mass can be neutralized with solid carbonates, such as calcium carbonate.

G. OXIDIZING AGENTS

The following discussion is limited to the inorganic oxidizing agents, because the organic agents, such as nitrobenzene, are often violent explosives and should come with special storage and handling instructions. Inorganic oxidizing agents include the chlorates, perchlorates, peroxides, and nitrates of barium, sodium, potassium, strontium, ammonium, etc. Their ability to furnish oxygen renders oxidizing agents hazardous, and violent explosions may occur when they are mixed or contaminated with minute quantities of certain carbonaceous and combustible materials such as wood, paper, metal powders, sulfur, etc. The violence of reaction depends upon subdivision, extent of contamination, degree of confinement, and type of inititation. Shoes, clothing, and other combustible materials covered with dust or solutions of oxidizing agents also represent dangers. Intimate mixtures of finely divided oxidizers and fuels are very sensitive to heat, friction, and impact.

H. HANDLING OXIDIZING AGENTS

1. Oxidizing agents shall be stored and processed only in fire-resistive rooms or buildings. They shall be separated from fuels, flammable materials, metal powders, and acids until processing.

2. Equipment for processing oxidizing agents shall not be used for fuels, flammable substances, metal powders, etc. It should be constructed of noncombustible materials only.

3. Solutions of oxidizing agents shall be placed in nonabsorbent, noncombustible containers only.

4. Damaged combustible containers shall not be repaired in the storage building because of the risk of contamination and ignition. Discarded containers shall serve no other purpose, but shall be burned in the open. Combustible containers infused with oxidizing agents burn fiercely if ignited, and may explode.

5. Employees handling oxidizing agents should wear flame-resistant clothing as minimal protection. Contaminated clothing should be stored in metal cabinets until laundered.

6. Spills of small quantities of oxidizing agents during processing must be cleaned up immediately. If large quantities are spilled, the uppermost layers may be salvaged if free of contaminants.

I. CHLORATES

1. Chlorates mixed with sulfur, sulfides, or other readily oxidizable material may cause spontaneous ignition. Sulfur presents a greater hazard than sulfides. Adding phosphorus to a sulfur-chlorate mixture increases

the danger. Shellac, potassium, sodium nitrate with petroleum derivatives, and powdered metals render chlorates sensitive; mixtures of trinitrocresol or picric acid and chlorates should be avoided since they are particularly sensitive. Chlorates must never be mixed with ammonium salts since the ammonium chlorate that could form could spontaneously explode. Moisture of 0.5 percent or more in mixtures containing chlorates is considered dangerous because of the possible formation of chloric acid.

2. Substituting sodium chlorate for potassium chlorate in any of the above-described mixtures increases the hazard.

3. Ammonium chlorate decomposes spontaneously. When mixed with perchlorates it constitutes a major hazard.

4. Barium chlorate is very toxic. In storage, it poses a greater danger than potassium chlorate.

5. Zinc chlorate, in contact with certain organic materials, explodes under the influence of slight friction, percussion, or shock. When involved in a fire, it is life-threatening.

6. Storage of chlorates should preclude contact with other combustible material, organic or inorganic. Broken or damaged containers and spilled material should be promptly removed and destroyed.

7. Fires involving chlorates should be fought with solid streams of water or with water fog. With solid streams, firefighters can maintain a greater distance but steam explosion becomes a danger requiring precautionary measures. Water fog offers the advantage of quicker cooling. Its normal smothering action, however, is obviated by the ability of chlorates to furnish oxygen to the fire.

J. PERCHLORATES

Perchlorates form slightly less sensitive mixtures than do chlorates and should be substituted whenever possible. Advantages of using perchlorates include this reduced sensitivity to impact and friction, the nonformation of a free acid when moisture is present, and greater safety in the event of accidental contact with the weak acids that form the principal part of many gums used in binding pyrotechnic mixtures.

1. Ammonium perchlorate alone does not easily explode. It is stable at ordinary temperatures, but decomposes at a maintained temperature of 302°F (150°C). It has the same degree of sensitivity to impact as picric acid. It becomes a high explosive when mixed with flammable materials and metal powders.

2. Containers for perchlorates and chlorates in storage include lined wooden boxes, kegs, barrels, and iron drums. All damaged and broken containers must be removed from the storehouse and spilled material swept up and destroyed promptly.

3. Fires involving perchlorates alone may be fought with water.

K. PEROXIDES

1. General

Solid peroxides decompose easily in the presence of moisture and must therefore be stored in a cool, dry place. They pose a severe fire hazard, particularly when incorporated with combustible materials. Sodium peroxide must be protected from contact with water, which renders it explosive. Hydrogen peroxide of approximately 30-percent strength is unstable, liberates oxygen, and resembles the solid peroxides.

2. High-Strength Hydrogen Peroxide

a. High-strength hydrogen peroxide (90 percent or greater) is shipped in specially designed containers with vents and stored only in containers vented to the atmosphere, constructed so that foreign material will not enter the containers. It must be stored in a cool, shaded location used only for that purpose. Containers of hydrogen peroxide must never exceed 15° or 20° above ambient temperatures. Larger increases in temperature may indicate a decomposition of the hydrogen peroxide. Operators shall report any undue heating of hydrogen peroxide drums to the person in charge, and the area shall be evacuated immediately. A water spray system, installed in every hydrogen peroxide storage location, must be turned on immediately upon observation of overheated storage drums. If hydrogen peroxide is to be stored for long periods, high-purity aluminum containers must be used.

b. All tanks, tubes, and fittings must be thoroughly cleaned. The recommended procedure involves immersing parts in a pickling solution of 0.5 percent sodium hydroxide at room temperature for 1 hour, washing with clear water, drying, immersing in a 5 percent solution of CP sulfuric acid at room temperature for 1 hour; washing, drying, and leaving in a 25 to 30 percent solution of hydrogen peroxide for at least 24 hours, then draining off the solution. The part is then ready for use.

c. Hydrogen peroxide burns and discolors skin. All persons handling this material should wear face shields, rubber gloves, and rubber trousers on the outside of rubber boots. Running water must be available in the storage area; any part of the skin touched by hydrogen peroxide must be immediately washed with water. Spillages of hydrogen peroxide must be immediately washed away with water.

d Only the following materials should be used in equipment coming in contact with high strength hydrogen peroxide: "Pyrex" glass, high-purity aluminum, pure tin, "Kerosal" or equivalent. Stainless steel types 304, 309, 310, 316, 321, and 347 are suitable for periods of 2 months or less.

3. Fires. Fires involving peroxides, except sodium peroxide, may be fought with water. Sodium peroxide fires must be smothered with sand, ashes, dirt, or rock dust.

L. NITRATES

1. General. Many nitrates are not flammable in themselves, and are usually stored in wooden boxes, kegs, or barrels. Ammonium nitrate, however, is shipped

in special waterproof bags or metal containers. Barium nitrate is sometimes stored in iron drums. Regardless of the type of container, it must be moisture-proof. Nitrates must be stored in a dry place, since they cake in the presence of moisture.

2. Ammonium Nitrate

a. Ammonium nitrate in confinement can detonate with the violence of a high explosive, but this would require a relatively heavy initiator. Under the effect of heating alone, ammonium nitrate will decompose. Contamination with chlorides, sulfur, nitrobodies, charcoal, metallic nitrates, metal powders, petroleum derivatives, and oxidizable carbonaceous materials sensitizes ammonium nitrate, accelerates its decomposition, and increases the violence of the reaction. Zinc or lead contamination lowers the decomposition temperature to 200° F. Galvanized metals and lead solder must not, therefore, be used in the vicinity of ammonium nitrate operations. The burning of ammonium nitrate and combustible material such as wood or paper containers, produces a gas mixture that under proper conditions of pressure may detonate with sufficient force to initiate the detonation of ammonium nitrate. Fires involving ammonium nitrate must be vented to the greatest practicable extent because air acts as a diluent for the hazardous gases, minimizing the probability of explosion.

b. In high pan (evaporating) operations, deluge systems should be provided over the pans for use in case of fire. Temperatures used to heat the liquor may not exceed 317°F (saturated steam at 100 psi). High pan operations must be located at class 1.1 distances from adjacent structures other than the graining building. The graining building, however, must be protected from the high pans by a barricade. The class 1.1 distances specified above may be based on the maximum quantity of ammonium nitrate contained in any one high pan.

c. Fires involving nitrate should be fought with large quantities of water, never with steam. Solid hose steams enable the fire to be fought from a greater distance but introduce the hazard of steam explosion, particularly if the nitrate is molten; therefore, the hose streams must be directed from behind a protective barrier. Under some circumstances, when the fire is in the incipient stage and accessible, water fog may be used to an advantage but it will have no smothering action since the burning material provides its own oxygen.

d. Storage of ammonium nitrate in explosives storage magazines is preferred. When stored in an area where there is a possibility that explosives may be projected into the nitrates, the requirements for class 1.1 explosives are applicable. When stored in an area with fire hazards only and separated by more than intraline distances from areas containing ammunition, ammonium nitrate may be stored in accordance with the requirements governing the storage of a class 1.3 solid propellant.

(1) Buildings, other than earth-covered magazines, used for the storage of ammonium nitrate, must be of a type easily vented if fire occurs, in order that the gases produced during combustion and considered potential sources of explosion to the commodity are dissipated. The floors of such buildings must be of a type to prevent hazardous impregnation by the nitrate.

(2) Stacking within storage buildings other than earth-covered magazines should anticipate stacks no larger than the 12 by 12 feet plan dimension, and not higher than 7 feet. Aisles not less than 3 feet wide must be maintained around each stack and between the sides of the building. The use of wood dunnage should be restricted to reduce the quantity of combustible materials present.

(3) Broken packages or containers shall be removed from the building and the spilled material swept up and destroyed promptly.

M. POWDERED METALS: ALUMINUM, MAGNESIUM, AND ALUMINUM ALLOYS

1. Since a rise in the temperature of metal powders can result from contact with water and ignition may ensue, precautions must be taken to prevent water from contacting the material. All buildings where powdered metals are stored or processed must be vented adequately at the highest point of the room or building to prevent the accumulation of evolved hydrogen gas that results from the reaction between powdered metals and moisture, except when stored in watertight containers.

2. Exposed material that may be at a low temperature should be brought to or near the room temperature under conditions of low relative humidity before being placed in the operating room.

3. Heating equipment must be installed in service magazines, when required, to bring the closed containers and contents to a temperature approximately that of the operating building.

4. Efforts should be made to maintain relative humidity between 50 and 55 percent in locations where metal powders are exposed, so as to avoid the hazard of static electricity while preventing condensation.

5. Operators should be cautioned to wear sweatbands on their foreheads and take other precautions to prevent perspiration from falling onto powdered metals.

6. Care should be exercised in locating pipes, to prevent condensation on cold pipes forming droplets of water and falling upon hazardous material. Leaking water pipes can cause ignition.

7. Powdered metals in metal containers with tight covers may be stored in general warehouses, provided that they are remote from oxidizing agents. The storage place must be dry.

8. When compounded with oxidizing agents, powdered metals present a dangerous fire and explosion hazard.

9. Very fine suspended dust from powdered metals is an explosion hazard comparable to that of explosive gases and may be initiated easily by discharges of static electricity.

10. Powdered metals exposed to air are dangerous fire hazards and burn with intense heat. Metallic oxide formed by the burning within drums effectively blankets such fires, confining them, if undisturbed, to the place of origin.

11. Fires must not be fought with ordinary streams of water because of the danger of liberating large quantities of hydrogen gas, a severe explosion hazard. Fires involving small quantities of powdered metals may be combated with a fog nozzle or specially designed commercial extinguishing powders gently applied to prevent the fire from spreading. If large quantities of powdered metals become involved in a fire and escape from their storage containers, firefighting efforts must be directed primarily to prevention of fire spreading to other facilities. Where friction sensitivity is not a concern, smothering fire with sand may be effective.

12. Trained personnel shall repair or maintain buildings or equipment where metallic powders are involved, and then only with the following precautions: powder or dust must be removed, nonsparking tools must be used, hammer impacts that could cause sparks must be avoided, flashlights must be of approved type, equipment must be grounded, undue friction must be prevented, and open flames must not be utilized. See NFPA National Fire Codes and NFPA Standards No. 63 and 48 (reference (i)).

13. Zirconium powder can explode violently when in contact with cupric oxide or lead oxide. Other metallic powders exhibit this property under certain conditions. NFPA 491M (reference (i)) provides information regarding reactions between metallic powders and other chemicals.

N. CHARCOAL

1. Charcoal is subject to spontaneous ignition in the presence of moisture, although pit charcoal is less likely to react than the chemical byproduct charcoal, and soft wood charcoal less so than hardwood charcoal. The following conditions promote the spontaneous ignition of charcoal: forced cooling after burning; drying after absorbing moisture; and contact with alcohols and oils (particularly for charcoal in which a fire has been extinguished). Pulverized charcoal is a definite fire hazard. The gases from burning charcoal contain carbon monoxide and are toxic.

2. Permanent or reserve storage of large quantities of charcoal is not recommended. Charcoal should be stored in airtight containers or in bags piled in tiers with skeleton or gridwork floors between tiers to provide ventilation. It should be isolated and remote from oxidizing agents. Bulk storage of charcoal is prohibited.

O. SULFUR

1. Sulfur compounded with chlorates and several other oxidizing agents forms highly sensitive explosive mixtures. Sulfur presents a spontaneous ignition hazard when mixed with carbon, lamp black, fats, and oils. Burning sulfur produces toxic gases and fumes.

2. Sulfur may be stored in wooden boxes, kegs, or barrels. Large quantities may be stored in bulk. It should be isolated and remote from oxidizing agents with which it forms highly sensitive explosive mixtures.

P. FLAMMABLE SOLIDS

Guanidine nitrate, dinitrophenol, DNT, and dinitrobenzene are examples of

flammable solids. These materials may be stored in wooden boxes or barrels lined with moistureproof paper. They should be stored in fire-resistant locations, preferably in magazines. When strongly initiated they may act as explosives. Dinitrophenol may explode at elevated temperatures.

Q. VOLATILE FLAMMABLE LIQUIDS

1. Common examples of volatile flammable liquids are ether acetone, gasoline, ethyl alcohol, methyl alcohol (wood alcohol), benzene, toluene, xylene, and amyl acetate. These volatile liquids may, if unconfined, evolve vapor in explosive concentrations. Ethyl and isopropyl ethers tend to form explosive peroxides, especially when anhydrous. Evaporation to near dryness must be prevented. Volatile flammable liquids must not be used to wash or clean equipment or parts of buildings except when specifically authorized as process requirements.

2. Some flammable liquids such as paints, varnishes, and enamels may, under certain conditions, be subject to spontaneous ignition. They must therefore be isolated from sources of heat, in locations where any heat produced will readily dissipate. Only noncombustible sweeping compounds should be used for cleaning up materials of this type.

R. CALCIUM CARBIDE

Small quantities of calcium carbide may be stored in general warehouses in airtight tin cans or iron drums. Large quantities should be stored only in separate noncombustible buildings or detached weatherproof sheds. The storage place should be dry and well ventilated. Calcium carbide, in itself a slight fire hazard, reacts violently with water, liberating large quantities of acetylene gas which, with air, forms explosive mixtures.

S. SODIUM HYDROXIDE (CAUSTIC SODA) AND POTASSIUM HYDROXIDE

These materials may be stored in general warehouses in airtight iron drums. Permanent storage of large stocks is not recommended. These chemical products may become a fire hazard when mixed with nitro compounds or other materials. Their action is corrosive and caustic; mixed with water, they create heat.

T. METALLIC SODIUM

Metallic sodium may be stored in airtight steel drums and may be stored under kerosene or nitrogen, but not under chlorinated hydrocarbons. Its violent reaction with water liberates hydrogen and causes heat, producing a serious fire and explosion hazard.

U. NITROCELLULOSE AND DERIVATIVES

Nitrocellulose includes various types of nitrated cotton or wood pulp, depending on the nitrogen content. When dry, it is extremely sensitive to shock and friction and readily accumulates static charges. It is highly flammable and explosive, burning rapidly and producing very little smoke or residue. Impure, it is subject to spontaneous ignition. Storage of dry nitrocellulose is not permitted as it possesses all the hazards of a sensitive

and easily ignited high explosive. Nitrocellulose with 25 to 30 percent moisture content is stored in zinc-lined boxes or metal drums and is substantially nonexplosive when stored in an area where explosives or ammunition cannot be projected into it.

V. RED PHOSPHORUS

Red phosphorus forms sensitive mixtures with oxidizing agents, posing a dangerous fire hazard. It may be stored in general warehouses in metal drums or metal containers included in wood boxes. Phosphine gas may form in containers of red phosphorous; protective measures should be used when opening these.

W. THERMITE (TH)

Thermite, a mixture of iron oxide, aluminum, and other substances, is a dark gray granular mass. To burn, it requires an igniter. At 4300°F, iron oxide reduces to molten iron, causing rapid burning. Thermate is a mixture of thermite, grained aluminum, barium nitrate, sulfur, and lubricating oil.

X. INCENDIARY BOMBS

Incendiary bombs may consist of a combustible body of magnesium metal alloy containing an igniter composition such as thermate. When ignited, the body of the bomb burns at about 3700°F. Other types (such as IM, NP, PTI) have steel cases filled with thickened fuel. These operate by ejecting the burning fuel over a wide area. Incendiary bombs are difficult to extinguish.

Y. COLORED SMOKE MIXTURES

These mixtures contain dye for smoke and some fuels. They do not contain hexachloroethane (HC). Respiratory protection shall be worn for protection against heavy concentrations of smoke.

Z. SMOKE

FM or FS in smoke form will not usually produce effects requiring treatment. Smoke in high concentrations from CN-DM, CN, and HC is toxic, and anyone unprotected by a mask subjected to this should receive medical attention. Corrosive on the skin, liquid FS or FM should be immediately washed with copious quantities of water, then flushed with mild sodium bicarbonate solution.

AA. ADAMSITE (DM)

DM is a greenish yellow to black solid, melting at 383°F. Smoke from the burning agent causes irritation in the nose and throat even in minimal concentrations. Longer exposure causes tightness of the chest, headache, sneezing, coughing, intense nausea, and weakness. The symptoms increase in severity for some time after exposure, and temptation to remove the mask should be resisted. Irritation produced by this agent is so intense that an intolerable concentration is reached long before it becomes dangerous to life. The effects may last for several hours, but no permanent injury is caused. If DM is spilled, it should not be swept or handled in any way so as to cause dust formation: DM should be wet thoroughly before it is swept. For first aid treatment, remove

victim to fresh air and flush nose and throat areas with bicarbonate of soda solution. Let victim breathe an alcohol, chloroform, and ammonia mixture. Evacuate to hospital for medical treatment.

AB. O-CHLOROBENZYLIDENE MALONONITRILE (CS)

1. CS is a white crystalline powder similar to, but more powerful than, CN. It has a minimum purity of 96 percent, insoluble in water and ethanol, it is soluble in methylene chloride. CS1 is a micropulverized powder. CS2 is a modified CS1, treated with liquid silicone to increase fluidity and persistency.

2. A protective mask; ordinary coveralls secured at the neck, wrist, and ankles; and rubber gloves, shall provide protection.

3. Exposure incapacitates within 20 to 60 seconds and, after the affected individual reaches fresh air, the effects continue for 5 to 10 minutes. Eyes burn, tear copiously, and involuntarily close. Exposure also causes coughing, difficulty breathing, chest tightness, a stinging sensation, a running nose, and dizziness or a swimming sensation in the head. Heavy concentrations of CS, which has a pepperlike odor, will also cause nausea and vomiting. To prevent stinging and reddening of the skin, personnel touched by CS dust or particles should not shower for 6 hours. Individuals affected by CS should move to fresh air, face the wind, and should not rub their eyes. To remove accidental gross contamination, personnel should remove clothing and immediately flush the body with copious amounts of water to remove most of the agent; apply 5 percent sodium bisulfite solution to remove remainder (except in or around eyes); then rinse the entire body.

4. Area decontamination is required with CS, which settles as a dust. Any such accumulation must be removed, either by vacuuming or washing down the area with detergent solution followed by a clear water rinse.

AC. SULFUR TRIOXIDE-CHLOROSULFONIC ACID MIXTURE (FS)

This is a heavy liquid acid with an acrid odor. It fumes strongly in air, decomposes above 154°F, and is used solely as a smoke-producing agent. Exposure to heavy concentrations may cause severe irritation to the skin, eyes, and respiratory tract. Inhalation of concentrated fumes causes coughing and strangulation, a constricted feeling around the chest, and a burning sensation in the nose and throat. When the mixture comes in contact with moisture, it forms hydrochloric and sulfuric acids, both of which corrode metals and fabrics. Any FS on clothing or skin should be wiped off with a dry cloth, and the contaminated area flushed with large amounts of water. Itself nonflammable, FS may cause fires if spilled on flammable material, particularly under damp conditions. Leaking munitions/containers should be removed from the magazine and contents poured on the ground in a suitable area. Spillage can be removed with large quantities of water. Small quantities of water added to FS react violently.

AD. TITANIUM TETRACHLORIDE (FM)

Titanium tetrachloride is a heavy, colorless liquid acid with a pungent odor. When it leaks it produces a massive amount of smoke. It is used solely

to produce smoke and has slight toxic effects. Liquid FM will burn the skin, however, and quantities of smoke cause a choking sensation and difficulty breathing; a protective mask is required for the comfort of the worker. In extremely heavy concentrations, protective mask canisters may become clogged to such an extent as to render breathing difficult; in enclosed places, serious injury can result. Large quantities of water can remove liquid FM from the skin. Leaking munitions/containers should be removed from the magazine and destroyed by pouring contents on the ground in a disposal area. Spillage can be removed with large quantities of water.

AE. HEXACHLOROETHANE MIXTURE (HC)

HC, a gray-colored powder without characteristic odor, consists largely of a hexachloroethane, zinc oxide, and aluminum mixture. HC reacts with water which can start it burning; it burns rather slowly with the evolution of a dense cloud of smoke. Respiratory protection shall be worn by personnel exposed to any concentration of HC smoke.

AF. BURNING MIXTURE (CN-DM)

CN-DM is a mixture of chloroacetophenone and diphenylamine chloroarsine with pyrotechnic materiel. Respiratory protection is required when this mixture burns.

AG. PHOSPHORUS MUNITIONS AGENTS

1. General. At present, white phosphorus (WP) and plasticized white phosphorus (PWP) are the only two chemical agents in this group; they have somewhat similar characteristics.

2. White phosphorus. WP is a yellowish, waxlike substance, melting at 110°F. Its most characteristic property is that it spontaneously ignites when exposed to air, burning with a yellow flame and giving off a large volume of white smoke. Smoke in field concentrations is not toxic, fumes are toxic. WP is intensely poisonous when taken internally.

3. Plasticized white phosphorus. PWP is finely divided WP suspended in a gel of rubber and xylene.

AH. STORAGE FOR PHOSPHORUS MUNITIONS

1 General. Phosphorus munitions should be stored in fire-resistive magazines with concrete floors or in igloo-type magazines in a manner facilitating inspection.

2. Temperature Control. White phosphorus filling in munitions becomes liquid at 111°F. When exposed to air, WP will ignite; in cases when a burster is in the projectile, it may explode. Below 111°F the filling is solid and will not leak; for this reason, the temperature shall be kept below 111°F.

3. Position of Munitions. Where temperature is likely to reach 111°F, WP munitions shall be stacked upright, sitting on their bases, so that a subsequent drop in temperature will not solidify the WP in a position affecting the ballistics of the item.

AI. SPECIAL PROTECTIVE EQUIPMENT FOR PHOSPHORUS MUNITIONS

1. General. Special equipment, including that required for first aid, should be readily available to personnel working where phosphorus munitions are stored, processed, or handled.

2. Personal Protective Equipment. Personal protective equipment consisting of flameproof gloves and coveralls and face shield, sufficient in number to equip all personnel required to work with phosphorus munitions, shall be centrally stored and maintained under close supervision. These items shall be issued to personnel working with WP- or PWP-filled items and shall be worn whenever munitions/containers leak.

AJ. FIRST AID FOR PHOSPHORUS BURNS

Phosphorus buried in the flesh is absorbed and may result in systemic poisoning. The tissues immediately around the burn are particularly affected by the absorbed phosphorus. Untrained personnel administering first aid should immediately plunge burned areas into water, then wrap them in wet gauze.

AK. LEAKING PHOSPHORUS MUNITIONS

1. General. White smoke immediately alerts observers to leaks in WP munitions. Spontaneous ignition occurs when air contacts the WP. Only prompt action can combat the great risk of fire posed by leaking WP munitions.

2. Immediate Action on Discovering Leaking Munitions. During operations, the person discovering the leaking munitions shall, when practicable, submerge the leaker in one of the tubs provided. (Rubber protective equipment does not give adequate protection when exposed to high temperatures such as produced by burning phosphorus. When burning phosphorus adheres to gloves, the gloved hands should be dipped in water.)

3. Disposal of Leaking Munitions. After a single leaking item has been immersed in water, it should be diposed of in an area where fragmentation will not be a hazard, smoke will not create a nuisance, and no dry vegetation could be ignited.

a. An item that does not contain a fuze or burster will be removed to the demolition ground and destroyed by static firing. All personnel must retire to a safe distance before the projectile is exploded.

b. The fire must be extinguished before a filled item with a fuze or burster, not in a container, is handled or moved. This is extremely hazardous, and shall be carried out under the direction of an expert in demolition techniques, familiar with chemical munitions. After the flames have been extinguished, the instructions given in paragraph AK.3., above, shall be followed.

AL. REMOVAL OF PHOSPHOROUS MUNITIONS

1. General. After leaked phosphorus has been doused and contained by water, the water can evaporate, making it possible for the phosphorus to reignite. Phosphorous that has self-extinguished by forming a crust can reignite if the crust is broken.

2. Procedures. Small amounts of phosphorus are best removed by first scraping with a putty knife or other such implement, then removing what remains with a blowtorch or similar appliance. This method of removing phosphorus must not be attempted until all loaded munitions have been removed.

3. Surveillance. The magazine should be kept under surveillance for at least 2 weeks, as fire may recur. Any deep cracks or crevices in the floor should be filled up with cement mortar before munitions are returned in the magazine.

AM. INCENDIARY AND SMOKE MUNITIONS

Munitions in this group include incendiaries and signaling smokes.

AN. SPECIAL PROTECTIVE EQUIPMENT FOR INCENDIARY AND SMOKE MUNITIONS

Boxed and unboxed incendiary and smoke munitions may be handled without special protective equipment. Respiratory protection should be available, however. Personnel exposed to burning munitions or bulk chemicals should wear protective masks.

AO. FIRST AID FOR INCENDIARY AND SMOKE MUNITIONS INJURIES

No unusual first aid treatment is required for personal injuries incurred handling incendiary-to-incendiary or smoke-to-smoke munitions. Burns should be treated in the same manner as those caused by flame. Persons exposed to high concentrations of smoke should be hospitalized.

AP. LEAKING INCENDIARY AND SMOKE MUNITIONS

Personnel handling leaking items need not generally wear protective equipment, but masks should be worn during exposure to burning munitions. Leaking munitions containing incendiary and smoke agents shall be segregated.

AQ. FIRE IN INCENDIARY AND SMOKE MUNITIONS MAGAZINES

In magazines containing incendiary or smoke munitions, primary firefighting efforts shall be confined to preventing fire from spreading. Water is not used to fight fires of thermite or mixtures containing fine metallic powders such as magnesium or aluminum. Incipient fires may be smothered by spraying with dry chemical fire extinguishers or covering with sand. Fire in magazines containing incendiary-to-incendiary or smoke-to-smoke munitions shall be fought with water only when large quantities of water can completely douse relatively small quantities of munitions.

CHAPTER 12

SAFETY STANDARDS FOR EXPLOSIVES FACILITIES

A. GENERAL

This chapter contains minimum safety standards for existing, new, or modified explosives facilities and equipment. For facilities primarily used for general industrial operations, the standards of this chapter will obtain in areas performing low-volume explosives work.

B. STANDARDS

Special properties of materials and operational hazards may require that national, Federal, and local standards be exceeded. In such cases, standards in this chapter will apply.

C. STANDARDS FOR BUILDINGS

1. Building Exteriors. Exterior wall and roof coverings of operating buildings should be noncombustible and, whenever possible, frangible, of "breakaway" construction. The buildings should have no basements and should not exceed one story, except to meet process requirements.

2. Interior Walls, Roofs, and Ceilings. Interior wall surfaces and ceilings of operating buildings which might house loose, finely divided explosives materials shall be smooth, free from cracks and crevices, fire resistive and, if painted, be covered with high-gloss paint, to minimize dust accumulation and facilitate cleaning. As further protection against dust, ledges should be avoided; any that exist shall be beveled or kept clean. Wall joints and openings for wiring and plumbing shall be sealed against dust. Roofs and walls should be as light as practicable, constructed and supported to vent an internal explosion upon formation of a few large fragments. Firewalls and dividing walls constitute exceptions. When class II hazard locations exist as defined by the National Electric Code (NEC) (reference (j)), suspended ceilings and hollow walls are prohibited in explosives facilities. Recommended practice is to install insulation and covering directly on the underside of the roof deck.

3. Floors and Work Surfaces. Floors and work surfaces in hazardous locations shall be constructed to facilitate cleaning, with no cracks or crevices in which explosives could lodge. Nonsparking floors and work surfaces are required in all locations where exposed explosives or hazardous concentrations of flammable vapor or gas are present. When grounding is necessary, conductive floors (mats or similar static-dissipating floor surfaces), tabletops, and other work surfaces shall be provided. Cove bases at the junctions of walls and floors are preferred. No exposed nails, screws, or bolts in work surfaces shall be permitted.

4. Substantial Dividing Wall

a. Substantial dividing walls, constructed in accordance with the requirements of TM 5-1300 (reference (d)), separate independent concentrations

of high explosives so they do not need to be added when determining Q/D requirements.

b. Openings in dividing walls for conveyors, pass-through boxes, or other uses, should be avoided. However, in locations where operationally necessary, the following apply:

(1) The opening(s) will not be larger than the minimum needed for the material's safe passage.

(2) Closures shall have equivalent wall-strength characteristics and fusible links.

5. Exits and Doors. No explosives hazard shall occupy space between an operator and an exit. Exit doors in buildings containing explosives, except storage magazines, should be casement-type and glazed with nonshatterable plastic material. All interior doors should open in the direction of the flow of material through the building and should open onto unobstructed passageways.

6. Emergency Egress. When standard exits and fire escapes do not provide for rapid enough egress from work levels above the ground floor, other means of emergency egress (that is, safety chutes) shall be provided.

7. Passageways. Weather-protected passageways between buildings or magazines should be of noncombustible construction and equipped with fire stops to interrupt a fire's progress.

8. Roads and Walkways. Good all-weather roads should be provided. Only roads serving a single magazine or explosives processing building (including its service facilities) may dead end, and then, only at the magazine or building. The road system should be designed to make it unnecessary to pass through an explosives area to travel from one place to another. Walkways and roads at the entrance to or between adjacent buildings containing explosives should be boardwalks or hard surfaced, preventing employees from tracking stones, grit, and other foreign material into operating buildings.

9. Windows and Skylights. Nonshatterable glazing is preferred where an explosion accompanied by falling or projected glass could cause injury. When glazing with conventional glass is used, the hazard may be reduced by covering it with properly fixed plastic or wire mesh screening.

10. Drains and Sumps

a. All drain lines handling explosive wastes shall have sumps or basins of sufficient capacity for the removal of explosives by settling. The drains shall be of adequate capacity; free of pockets; and with slopes of at least one-quarter inch per foot to prevent explosives settling-out in the drain line, rather than in the sump or settling basin intended to collect them. Sumps shall be so designed that suspended and settleable solid explosive material cannot be carried beyond the sumps in the wash waters, and so overflow will not disturb any floating solids. The settling rate of the material and the usual rate of flow shall be taken into account in determining the sump's capacity.

The design shall also permit easy removal of collected explosives, and shall allow for retention of those that float on water until they can be skimmed off. Bolted sump tanks or other types of construction that permit the explosives to settle in obscure or hidden spaces are prohibited.

b. Care shall be taken to preclude deposition of explosives from sump effluent due to drying, temperature changes, or interaction with other industrial contaminations. Sweeping and other dry collecting measures should be used to keep appreciably water soluble explosives out of the drainage system.

c. Drains between the source of explosive and the sump shall be troughs with rounded bottoms and with removable ventilated covers to facilitate inspection for accumulation of explosives. Waste liquids shall not be run into closed drains and sewers. Drains shall be inspected periodically and necessary steps taken to prevent the buildup of explosives deposits in them. Drains and sewers containing explosive waste materials will not be connected in a manner to empty such wastes into the normal sewage systems carrying inert or sanitary wastes.

11. Hardware

a. Hardware in buildings containing exposed explosive materials, explosive dusts, or vapors should be of nonsparking material. Installation of hardware (piping and ducts) should not be affixed to blowout panels or walls.

b. Fasteners such as nuts and bolts which could accidentally drop into explosives or explosive constituents shall be prevented from doing so by being drilled and thonged or otherwise secured.

12. Ventilation. Exhaust fans through which combustible dust or flammable vapor pass shall be equipped with nonferrous blades, or the casting shall be lined with nonferrous material. Motors shall be of the proper class (NEC) for the hazard. Exhaust systems shall be cleaned and serviced on a regular schedule. The entire system shall be bonded and grounded.

13. Steam for Processing and Heating. Process steam is that which is in direct contact with explosives, used directly in their manufacture; or that which, in case of equipment failure, would exhaust directly into contact with explosives or explosive fumes. Steam used for heating operating buildings containing explosives should have a maximum pressure of 5 psi (228°F). When necessary, process steam may exceed 5 psi, up to 15 psi. The exterior of steam or hot water pipes in contact with wood, paper, or other combustible materials shall not exceed 160°F. When steam temperature must exceed 228°F in hazardous locations, steam lines shall be covered and painted with an impervious material or otherwise protected against contact with explosives. Requirements for steam pressure exceeding 15 psi must be evaluated by the contracting officer on a case-by-case basis. When a reducing valve is used, no relief valve shall be bypassed in a manner permitting circumvention of the pressure reduction equipment. The production of superheated steam caused by the throttling action of reducing valves must be prevented. Use of a "water leg" or water column to control steam pressure of 5 pounds or less is recommended. When close control of steam temperature is necessary, indicating and recording pressure or temperature gauges shall be installed. Such devices should be tested periodically and the test results recorded. When electrical resistance to ground is high, steam lines shall be properly grounded where they enter buildings.

14. Tunnels. To prevent possible communication of an explosive, shock wave and blast shall receive special consideration in designing and contructing tunnels between buildings containing explosives.

D. ELECTRICAL STANDARDS

The installation and use of electrical equipment within explosives buildings, magazines, and explosives facilities shall comply with the latest edition of NEC, at a minimum, except as otherwise specified herein. In planning electrical equipment for special occupancies or for hazardous locations as defined in the NEC, it is often possible to locate equipment in less hazardous or nonhazardous areas, reducing the quantity of special equipment required and decreasing the hazard.

1. Hazardous Locations

a. Electrical equipment and installations in hazardous locations (classes I, II, and III, as defined in the NEC) shall in all cases comply with the requirements of the code for division 1.

b. When electrical equipment is installed in those areas that fall into the categories of both class I and class II, the equipment shall be of a type used in both locations. The installations shall be in accordance with the requirements for class I hazardous locations.

2. Alternate Power Source. In special processes and operations requiring a continuous supply of power, provisions shall be made for an alternate source.

3. Transmission Lines. To prevent broken wires from hitting the building, the distance separating overhead transmission and service lines from magazines and buildings containing explosives shall be greater than that between the poles supporting the lines. In no case shall overhead transmission lines pass within 50 feet of magazines or other explosives buildings. Service lines of all types shall, except for local telephone connections and similar low-voltage intercom or alarm systems, be run underground from a point at least 50 feet away from the building.

4. Motors. Electric motors should not be installed in class I or class II hazardous locations. They should be outside any such room or building. They should be connected to the process building only through mechanical glands or apertures adequately sealed against entrance of hazardous materials into both the location where motors are positioned and the motor enclosure itself.

5. Motor Controls, Circuit Breakers, and Safety Switches

a. Circuit breakers, safety switches, service entrance switches, and speed controllers for hazardous locations should be installed on steel racks:

(1) In separate buildings connected only by electrical conduits between the small building housing the control equipment and the buildings containing the electrical equipment for hazardous locations. Such conduits shall be provided with sealing fittings to prevent communication of flame or arcs from the starters to the hazardous area.

(2) On the outside walls of buildings considered hazardous locations.

b. Limit switches, pressure switches, float switches, and any other control devices which for practical operating reasons cannot be located outdoors shall bear the approval of the Underwriters' Laboratories, Inc., or other approved testing agencies. Electrical conduit connections to such equipment shall comply with the requirements of the latest edition of the NEC (reference (j)) for the specific hazard.

c. The primary electric supply to an entire explosives area should be so arranged that it can be cut off by switches located at one or more central points away from the area.

6. Flashlights and Lanterns. Flashlights and hand lanterns powered by low-voltage dry cell batteries and miners' cap lamps, approved as "Permissible" by the United States Bureau of Mines or, for class I hazardous locations, by Underwriters' Laboratories, Inc., may be used in both class I and class II hazardous locations.

E LIGHTNING PROTECTION

Lightning protection systems shall be installed and maintained in accordance with the NFPA Lightning Protection Code (reference (i)) at a minimum.

F. STATIC ELECTRICITY AND GROUNDING

1. Detailed discussions of the hazards of static electricity and ways of reducing it are published by the National Fire Protection Association, Underwriters' Laboratories, Inc., the United States Department of Commerce, and the Bureau of Mines, U.S. Department of the Interior. Where static spark discharge may be hazardous, NFPA 77, "Static Electricity" (reference (i)) shall apply, except as otherwise specified herein.

2. Grounding of Equipment. Bonding straps shall bridge contact points where oil, paint, or rust could disrupt electrical continuity. Permanent equipment in contact with conductive floors or tabletops is not considered adequately grounded. Static grounds shall not be made to gas, steam, or air lines, dry pipe sprinkler systems, or air terminals of lightning protection systems. They may be made to water pipes, ground cones, buried copper plates, driven ground rods, or to down-conductors of lightning protection systems. All grounds must be interconnected if a structure is equipped with a lightning protection system. Metallic bonding and grounding cables, straps, or clamps shall be compatible with the explosives being processed.

3. Belts. Conductive belting shall be used wherever static is a hazard. Such belting shall have a resistance to ground not exceeding 600,000 ohms. Static combs must not be used to drain off static generated from belting or pulleys used in the presence of hazardous concentrations of explosives dust or flammable vapors.

4. Testing Equipment Grounds. Grounding systems shall be tested for electrical resistance and continuity when installation has been completed and, in the case of active equipment, at locally determined intervals.

The ground systems of equipment inactive longer than 1 month shall be visually inspected for resistance and continuity before reactivation. All exposed explosive or hazardous materials shall be removed before testing. All test records should be kept. In ground-resistance testing, equipment should be considered as a unit. All conductive parts of equipment shall be grounded so that resistance does not exceed 25 ohms, unless 10 ohms is required for lightning protection. To ensure compliance with ohmic requirements, resistance of the belting is to be excluded in measuring the total resistance to ground for belt-driven machinery. The rate of static generation should be considered before changes in grounding systems are made.

5. Conductive Floors. Conductive floors and conductive shoes shall be used for grounding personnel at operations with exposed explosives with electrostatic sensitivity of 0.1 joule or less, such as primer, initiator, detonator, igniter, tracer, and incendiary mixtures. Materials sensitive to static sparks, easily ignited or detonated, include lead styphnate, lead azide, mercury fulminate, tetrazene, diazodinitrophenol, potassium chlorate-lead styphanate mixtures, igniter compositions, grade B magnesium powder, and exposed layers of black powder dust. Dust from solid propellants can be ignited from spark energy, making conductive floors and shoes necessary where such dust is present. Air and dust mixtures of ammonium picrate, tetryl, tetrytol, and solid propellants are also sensitive to static electricity discharge. Many flammable liquids and air mixtures tested (ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) can be ignited by human static discharge. Therefore, areas where personnel might come into contact with the kinds of explosives or mixtures enumerated above shall be equipped with conductive floors, except when the hazards of dust/air or flammable vapor/air mixtures are eliminated by adequate housekeeping, dust collection, ventilation, or solvent recovery methods.

a. Conductive floors are also required when operations involve the following:

(1) Loose, unpacked ammunition with electric primers.

(2) Exposed electro-explosive devices such as squibs, detonators, etc.

(3) Electrically initiated items, such as rockets, with exposed circuitry.

(4) Hazardous materials that could be ignited by human static discharge.

b. When a hazard remains localized, conductive floors and footwear are not required throughout an entire building or room. In such cases, conductive mats or runners may be used. These mats and runners must meet all the specifications and test requirements that apply to conductive floors.

6. Conductive Floor Specifications. Conductive floors, made of nonsparking materials such as lead, conductive rubber, or conductive flooring compositions, shall meet the following requirements:

a. The flooring and its grounding system must provide for electrical resistance not to exceed 1 million ohms.

b. The surface of the installed floor must be free from cracks and reasonably smooth, and the material must not slough off, wrinkle, or buckle under operating conditions. Conductive tiles are not recommended for areas where explosives dust can cause contamination, because the large number of joints, and the tendency of tiles to loosen, create areas where explosives dust can lodge, not amenable to normal cleanup procedures. Where conductive floors and shoes are required, the resistance of conductive shoes on a person plus the resistance of floor to ground shall not exceed 1 million ohms total. Tabletops used with exposed explosives or dusts should be covered with a properly grounded conductive material meeting the same requirements as those for the flooring. The conductive floors must be compatible with the particular materials to be processed.

7. Initial tests of conductive floors shall be followed by others at least semiannually. The test results should be permanently recorded. Testing shall proceed only when the room is free from exposed explosives and flammable gas mixtures.

a. The resistance of the floor shall be more than 5,000 ohms in areas with 110 volts service and 10,000 ohms in areas with 220 volts service, and less than 1 million ohms in all areas as measured between a permanent ground connection and an electrode placed at any point on the floor and also as measured between two electrodes placed 3 feet apart at any points on the floor. Measurements shall be made at five or more locations in each room. If the resistance during a measurement changes appreciably with time, the value observed after the voltage has been applied for about 5 seconds shall be considered to be the measured value. These resistance values do not apply to metallic floors.

b. The operation and maintenance of test instruments shall be entrusted to competent personnel.

8. Humidification. Humidification that maintains relative humidity above 60 percent effectively prevents static electricity accumulations and subsequent discharges. This technique involves preoperational checks and regular monitoring of the humidity levels throughout the day. It cannot be used with metallic powders, some pyrotechnic mixtures, and other materials susceptible to spontaneous ignition in air with 60 percent relative humidity.

9. Ionization. Ionization is electrical neutralization and serves as an effective method of removing static charges from certain processes and operations. Methods of application can be found in NFPA Standard 77, "Static Electricity" (reference (i)). Ionization methods of removing static charges must not be used in hazardous locations as defined in the NEC (reference (j)).

CHAPTER 13

SAFETY STANDARDS FOR SPECIFIC EXPLOSIVES MATERIALS AND OPERATIONS

A. GENERAL

This chapter provides the minimum safety standards necessary for the prevention of mishaps involving specific explosives materials and operations that, unless properly controlled, make casualties to personnel, material, equipment, and facilities highly probable. They apply to similar operations and equipment, specifically addressed or not. These standards, to be used as a basis for developing local program requirements, are in no way comprehensive. The contractor is responsible for analyzing each operation and developing procedures to control or eliminate actual or potential hazards.

B. PROPERTIES OF EXPLOSIVES

Knowledge of properties of specific types of explosives is critical to the establishment of proper hazard controls.

1. Properties of Initiating Explosives. Initiating explosives include lead azide, mercury fulminate, lead styphnate, and tetracene. They manifest extreme sensitivity to friction, heat, and impact. When involved in a fire, they can be expected to detonate without burning. In storage, initiating explosives shall be kept wet with water or water/alcohol mixtures. Every effort shall be made to prevent the liquid from freezing; frozen explosives material will not be handled. Emphasis must be placed upon cleanliness and general housekeeping since contamination of these explosives with foreign, particularly gritty, material markedly increases their sensitivity. Water used for storage must be free of bacteria-forming impurities which could react to form gases. Lead azide shall not be allowed contact with copper, zinc, or alloys containing any concentration of such metals because of the likely formation of other azides that are more sensitive than the original lead azide. Likewise, mercury fulminate shall not be allowed contact with aluminum, magnesium, zinc, brass, or bronze.

2. Properties of Boostering Explosives. Explosives used for this purpose include tetryl, RDX, PETN, and RDX with added ingredients. These explosives have sensitivities between initiating explosives and those of explosives used as bursting charges such as TNT. They may be ignited by heat, friction, or impact and may detonate when burned in large quantities or at too great a depth. Some of these materials are toxic when taken internally or by skin contact and special precautions are necessary to protect personnel. Local exhaust ventilation, enclosed process systems, automatic handling systems, etc., should be used to minimize dust in the employee's breathing zone.

3. Properties of Bursting Explosives. Bursting explosives include explosive D (ammonium picrate), amatol, picric acid, TNT, tritonal, RDX compositions, HMX compositions, torpex, DBX, and HBX. In general, these materials are less sensitive than initiating or boostering explosives. Alkaline cleaning agents or other alkaline products should not be permitted in buildings where large quantities of these explosives are handled. Amatol forms sensitive

compounds with copper and brass. Where explosive D is processed, lead fusible links and solder-type sprinkler heads should not be used. DBX is an aluminized explosive that is somewhat hygroscopic and reacts with metals in the same manner as amatol. HBX is also an aluminized explosive that outgasses when exposed to water and may create internal pressure when loaded into ammunition. HMX compositions usually result in a very powerful explosive with a high degree of thermal stability. Pentolite tends to separate into its ingredients (PETN and TNT) and should therefore be handled as carefully as PETN. Picratol is a mixture of TNT and explosive D; the precautions necessary when handling either must be observed. Picric acid is highly acidic, corrosive, and toxic; it must be isolated from lead and lead compounds. Tetrytol is a mixture of tetryl and TNT which is stable in storage but exudes at 149°F. Dry tetrytol slightly corrodes magnesium and aluminum alloys, and wet tetrytol slightly corrodes copper, brass, aluminum, magnesium, mild steel, and cadmium-plated mild steel. TNT is stable and does not form sensitive compounds with metals. It will, however, form sensitive compounds in the presence of alkalies. It also exhibits well-recognized toxic properties. Torpex is an aluminized explosive used mainly in underwater ordnance. Nonhygroscopic and noncorrosive, it is stable in storage but may outgas (hydrogen) and produce internal pressure when loaded into ammunition. Tritonal is a mixture of TNT and aluminum power and is more sensitive to impact than TNT. Tritonal must not be exposed to water. Plastic bonded explosives are conventional high explosives with plastic binders such as polystyrene, viton, estane, etc. Their sensitivity varies with the composition. The series most frequently encountered are identified by prefix PBX or LX and a number.

4. Properties of Other Explosives. Other military explosives frequently encountered include black powder and nitroglycerin. Black powder is a mixture of potassium or sodium nitrate, charcoal, and sulfur, highly sensitive to friction, heat, and impact. It deteriorates rapidly on absorption of moisture but retains its explosive properties indefinitely if kept dry. Nitroglycerin's extreme sensitivity to impact and friction is such that it is manufactured only as needed. Frozen nitroglycerin, while less sensitive than liquid, may undergo internal changes upon thawing and, if enough heat is generated, may detonate.

5. Research of Additional Properties. The foregoing does not comprehensively catalog explosives and properties, but indicates how significantly they can differ. For this reason, it is imperative that contractors investigate pertinent properties before handling these or other explosive materials. Contractors are responsible for understanding all aspects of ammunition and explosives needed to fulfill contractual obligations.

C. HANDLING LOW-ENERGY INITIATORS

Typical precautions, such as shielding and safety glasses, shall be supplemented by the following measures, as appropriate, when manufacturing, processing, using, or testing low-energy initiators (initiated by 0.1 joule of energy or less).

1. All metal parts of equipment shall be electrically bonded together and grounded.

2. Personnel shall wear clothing that prevents generation of static electricity. Conductive shoes shall be tested with a resistance meter before an operator enters an area where low-energy initiators are being processed.

3. When low-energy initiators are being handled, personnel shall be directly grounded by wrist straps. The resistance reading, taken once daily when the operator is wearing the strap, shall be less than 25,000 ohms when measured from opposite hand to ground. Special contact creams may be used to decrease the resistance to the required value.

4. Glass, acrylic, or polycarbonate materials required for transparent shielding shall be periodically coated with an antistatic material to prevent buildup of static electricity.

5. The sounding of a static electricity alarm, installed with the setting best able to provide ample warning, signals that work shall stop until the problem has been located and corrective action taken.

6. Work will not start in air-conditioned areas until relative humidity and temperature have been checked.

7. No metal surface subjected to rubbing or friction shall be painted. If a lubricant is necessary, it should be of a composition that will not increase the metal's surface resistance above 25 ohms.

8. Work on or with initiators shall be performed in areas equipped with conductive floors and tabletops. Exceptions may be made when the initiators are in their original packaging, or are part of a finished metallic end item affording them complete protection from electromagnetic or electrostatic energy.

9. Work will not be done in the vicinity of actual or potential electromagnetic or electrostatic fields. Sources of static electricity and electromagnetic energy include radio transmission, electrical storms, transformer stations, high voltage transmission lines, improperly grounded electric circuitry, rotating equipment, belts, etc. Adequate lightning protection and grounding and adequate resistances for fixed sources of energy shall be established for locations with low-energy initiator operations. These shall be shielded to afford protection against local mobile radio transmission.

10. Electrical equipment shall be located out of the range of an operator working with a low-energy initiator. With soldering irons, it may be advisable to ground and limit energy to levels below initiating thresholds.

11. When not part of an end item or end item subassembly, initiators shall be transported only when packed according to the latest packing specifications for low-energy initiators.

D LABORATORY RESEARCH, DEVELOPMENT, AND TESTING OPERATIONS

1. Research and development laboratories and testing facilities constitute a separate category involving guidance, restrictions, and the waiving of certain requirements prescribed in this Manual.

2. Each operation at blast and fragment confinement facilities shall be reviewed to ensure that the explosives limits are within the laboratory or test area capability prescribed in this Manual. Facilities shall completely confine blast and fragment hazards, eliminating the need for public traffic route and inhabited building distances. Explosives limits and safe separation distances must be adjusted as the capability to confine fragment and blast decreases.

3. A total-confinement facility must be inspected after a detonation to ensure structural integrity, possibly reducing the explosives limits to prevent future blasts from exceeding the retention capability.

4. Each proposed program for the laboratory or test facility shall be reviewed to determine all potential hazards. Considerations shall include:

a. Structural limitations of the facility.

b. Remote control viewing and operating equipment, if required.

c. Special safety precautions for personnel elsewhere in the building.

d. Safe separation distances.

e. Required deviations from other parts of this Manual.

f. SOPs, which shall at a minimum include the following:

(1) Protective clothing.

(2) Warning signals.

(3) Fire and other emergency procedures.

(4) Special testing of equipment needed before operations (such as stray voltage and calibration checks).

(5) Removal of all explosives not needed for the operation.

(6) Arrangements for overnight storage of necessary explosives.

(7) Inspection and cleanup procedures after a test or detonation.

5. Laboratories shall use no more explosives than absolutely required for a given operation. Particularly hazardous laboratory operations involving new or relatively unknown explosives should be done by remote control. Operational shields shall be used in these operations and in new or untested applications of explosives.

6. When laboratories and testing facilities cannot be properly shielded to prevent the release of fragments and blast, the following apply:

a. The minimum incremental safe separation distances of tables 13-1 and 13-2 shall apply to operations, facilities, and personnel of the establishment except as indicated in paragraph D.6.b., below.

Table 13-1. CLASS 1.1 - Quantity/Distance (Laboratories).

Quantity of Explosives		Distance in Feet*		
Pounds (Over)	Pounds (Not Over)	Inhabited Building	Public Traffic Route	Intraline
0	1	40	25	20
1	2	50	30	25
2	5	70	40	30
5	10	90	55	35
10	20	110	65	45
20	30	125	75	50
30	40	140	85	55
40	50	150	90	60

*The above distances may be used only when structures, blast mats, etc., can completely contain fragments and debris. If fragments cannot be contained or the quantity of high explosives exceeds 50 pounds, then the distances shall be obtained from the Q/D tables.

Table 13-2. CLASS 1.3 - Quantity/Distance (Laboratories).

Quantity of Explosives		Unbarricaded Distance in Feet		
Pounds (Over)	Pounds (Not Over)	Inhabited Building	Public Traffic Route	Intraline
0	5	10	10	10
5	10	15	15	15
10	20	20	20	20
20	30	25	25	25
30	50	30	30	30
50	80	35	35	35
80	100	40	40	40
100	150	45	45	45
150	200	50	50	50

b. When facilities and roadways warrant the protection equal to that required for the general public, the minimum safe separation distance shall be 1,250 feet.

7. If the proposed storage facilities will confine the blast and fragments, or if the incremental safe separation distances are as indicated in paragraph D.6., above, up to 15 pounds of explosives may be stored without consideration of storage compatability. However, the operation must be reviewed, as stated in paragraph D.4., above.

E. ELECTRICAL TESTING OF AMMUNITION AND AMMUNITION COMPONENTS

1. Type of Test Equipment. Electrical and electronics test equipment should use the weakest possible power source. Batteries shall be preferred to 110-volt power sources. No power source should be capable of initiating the explosives item being tested. When exceptions must be made because more power is needed, steps must be taken to prevent delivery of power to the explosives item in quantities sufficient to initiate it. Safeguards must be provided against the admitted possibility of human error.

2. Layout of Test Equipment. Test equipment shall be placed in hazardous atmospheres only when absolutely necessary. Unless the test equipment is, under all circumstances, incapable of initiating the test item, operational shields are required for personnel protection. The most reliable way of attaining and retaining this initiation incapability is by protecting the test equipment, including leads, from electromagnetic induction and radiation fields and electrostatic energy, and by providing the test equipment with a weak power source.

3. Use of Test Equipment. Test equipment shall be used only as intended by original design. The equipment shall be maintained by qualified personnel, with operator adjustments limited to those required for testing.

F. HEAT-CONDITIONING OF EXPLOSIVES AND AMMUNITION

1. All ovens, conditioning chambers, dry houses, and similar devices and facilities shall be provided with dual independent fail-safe heat controls. For devices or facilities heated by steam only, the requirement for dual heat controls shall be satisfied if the steam pressure is controlled by a reducing valve (maximum pressure of 5 psi, unless otherwise authorized) on the main building steam supply, and a thermostat.

2. Heat-conditioning devices shall be able to discharge overpressure from an internal explosion. Barriers or catching devices shall restrain blowout panels, doors, and other venting apparatus, to prevent excessive displacement during an accidental explosion.

3. Heat-conditioning devices shall be vented to permit any gases produced to escape.

4. Steam should be used to heat conditioning devices; when electric heating elements are unavoidable, they shall be located where there is no possibility of contact with explosives or flammable materials.

5. The blades of a fan in a heat-conditioning device shall be of non-sparking material; its electric motor shall be installed externally. The air must not recirculate if the heating surfaces exceed 228°F or if the air contains materials that could collect on the heating coils.

6. Electrical equipment and fixtures in or on a heat-conditioning device used for explosives or flammable material shall be approved for use in the hazardous atmosphere in question.

7. The interior of a heat-conditioning device shall be free of crevices, openings, and other protuberances not easily cleaned, where dust or flammable material could lodge.

8. All noncurrent-carrying metal parts of a heat-conditioning device shall be interconnected and electrically grounded.

9. Heat-conditioning devices should be installed in isolated locations, set up to give personnel maximum protection from the effects of an incident. When warranted, operational shields and other personnel protection measures shall be used.

10. Safe separation distances or protective construction shall ensure against an explosives incident in one heat-conditioning device from propagating to others. No hazardous materials shall be placed in a room or cubicle containing a heat-conditioning device, unless it can be shown that an accident in the conditioning device would not involve the other materials.

11. Heat-conditioning device operating procedures require:

a. Limiting the explosive materials in the device to the type and quantity authorized for the specific device.

b. Familiarity with the critical parameters of explosives compositions before processing in a heat-conditioning device. The device shall not exceed limits established for the hazardous composition being conditioned.

c. Checking heat-conditioning device temperatures at specified intervals during operation.

d. Cleaning the conditioning devices, ducts, vacuum lines, and other parts of the equipment subject to contamination by hazardous materials, before introducing a different item or composition for conditioning.

G. SPRAY PAINTING

1. Loaded ammunition shall not be electrostatically spray painted.

2. Water wash or dry filter-type spray booths shall be used for loaded ammunition.

3. Controls for ventilating fan motors for spray painting booths shall be interlocked with the controls for the paint sprayer. With this arrangement, failure of the ventilating system will shut off power to the paint sprayer.

4. High-voltage electrically powered paint-spraying equipment shall be installed in accordance with the requirements of NFPA Standard No. 33 (reference (i)), as applicable.

5. Conventional equipment used for spray painting in standard spray booths shall meet the requirements of NFPA Standard No. 33 (reference (i)). The nozzles of all spray guns shall be electrically grounded because of the static electricity generated.

H. DRYING FRESHLY PAINTED LOADED AMMUNITION

Ovens used in drying loaded ammunition shall comply with the National Fire Codes (reference (i)). Other requirements include the following:

1. Automatic thermostatic controls shall regulate temperatures once they reach a maximum determined by the ammunition and explosives involved. It is recommended that temperatures not exceed 170°F.

2. Automatic internal sprinkler systems shall equip each oven and shall conform with "Sprinkler Systems" NFPA Standard No. 13 (reference (i)). Automatic operation of the system may be accomplished by approved electrical heat-actuated devices, installed as required for NEC-defined class I, division 1, group D, hazardous locations (reference (j)).

3. Hot air or other means may supply heat, provided ammunition and explosives are kept from contact with coils, radiators, and heating elements.

4. In case of power failure, the heat supply for any conveyor system shall automatically stop.

5. Electric drying units that are not approved for use in class I hazardous locations (reference (j)) should be designed so that solvent vapor concentration in the oven is kept below 25 percent of its lower explosive limit.

I. REWORK, DISASSEMBLY, RENOVATION, AND MAINTENANCE

1. Rework and disassembly operations shall not usually be conducted with other inert or explosives operations. However, when concurrent scheduling cannot be avoided, operations shall be sufficiently distanced from one another to protect adjacent personnel and equipment, and prevent propagation to adjacent explosives. Such separation may be accomplished with Q/D, operational shielding, or the remote control of operations.

2. The operator and all other personnel must be fully protected during rework and disassembly operations known or expected to use force exceeding assembly specifications.

3. If A&E items have been assembled normally, the same equipment, tools, methods, and applied forces may be used to disassemble them. In such cases, only that personnel protection required during the assembly operations is also required during the rework or disassembly operations. Care must be taken, however, to ascertain that the assembly was normal and that the surfaces to be separated are not corroded and not sealed with metallic applicants.

4. When renovation or maintenance not adequately addressed in the contract is required, the contractor shall request specific safety guidance through contract channels.

J. MUNITIONS LOADING AND ASSOCIATED OPERATIONS

1. Screening and Blending High Explosives. Bulk high explosives intended for processing shall be screened or visually inspected and passed over a magnetic separator to detect extraneous material for removal. Screening equipment shall not subject explosives to pinching, friction, or impact. Explosives screening units without exhaust ventilation must be thoroughly cleaned as often as necessary and after every shift, to prevent hazardous accumulations of explosives dusts.

2. Screening and Blending Initiating Explosives. Suitable operational shields shall be provided for screening and blending operations involving initiating explosives, or operators shall be located at intraline distance from screening and blending facilities.

3. Explosives Melting

a. Temperatures used for melting explosives and keeping explosives molten should not exceed 228°F. However, steam pressures up to 15 psi (250°F) may be used to melt composition B and similar binary explosives and to maintain a molten state.

b. Melt unit valves and melt mix draw-off or other lines carrying molten explosives shall provide against friction or impact capable of initiating the explosives. Diaphragm-type valves should be disassembled and inspected regularly. Damaged or old diaphragms shall be replaced so no cracks allowing metal-to-metal contact can develop. Draw-off lines should be constructed to prevent exposure of threads, fastening screws, and bolts, both outside and between the flanges. A sealing compound should be used to prevent explosives seepage or vapor condensation on the contacting surfaces of the bolts, flanges, screws, and nuts. Melt mix kettle draw-off pipes should be electrically connected to items being filled during draw-off operations. Items shall be individually grounded unless tests show that grounding through contact surface is adequate.

c. Wet-type collectors effectively remove dust and vapors from exhausted air, and are recommended for melt mix exhausting systems. Water in the wet collector will not be recirculated unless the system removes hazardous suspensions. Water retaining such explosives shall be discharged to a sump designed to keep such explosives wet. The exhaust and collecting equipment will be regularly inspected and flushed of explosives accumulations. When protective construction prevents propagation of a detonation between melt kettles, a complete dust and vapor collection system shall equip each kettle.

4. Agitation. Agitation nitrators, washers, and other machines which, because of the hazard of the process and the possibility of the process material decomposing, are equipped with mechanical agitators, shall have at least two means of agitation, each operating from an independent power source to maintain agitation if one fails.

5. Machining of Explosives

a. High explosives, cased or uncased, that may be machined without special personnel protection and without coolant, if no metal-to-metal contact is involved, include: Amatol, Octol, TNT, composition B, explosive D, and RDX/TNT compositions containing 60 percent or less RDX.

b. High explosives, cased or uncased, that may be machined without special personnel protection provided a coolant is directed on the tool and explosives at their point of contact and no metal-to-metal contact is involved, include: baratols, pentolite (50-50 and 10-90), tetrytol, and cyclotols (composition B less than 60-40; that is, 70-30).

c. When essential, other high explosives may be machined by remote control, with the operator protected by a suitable operational shield; however, initiating explosives should not be machined if desired shapes or sizes can be obtained by other means, such as forming.

d. When an unprotected operator is involved in drilling, only a single drill, with a diameter greater than 1/4 inch, shall be used.

e. Machining of cased explosives is permitted in an operation requiring removal of metal before or after tool contact with the explosives filler, provided that operators are protected by operational shields and perform it by remote control.

f. Where wet machining is to be performed, automatic interlocking devices shall prevent machining from starting until coolant is flowing. These controls must also be capable of stopping the machining if the coolant flow is interrupted. When coolant flow must stop for adjustment of machining tools, positive means must be devised to ensure that flow of coolant is restored and all automatic control devices are operating before machining can resume.

g. The lineal and rotational speeds of tools used for the machining of explosives shall be maintained at the minimum necessary to perform the operation safely and efficiently. These shall not exceed 210 linear feet per minute nor 525 revolutions per minute. The rate of feed should likewise be the lowest consistent with safety and efficiency, based on the explosive materials being machined.

h. Pneumatically or hydraulically driven machine tools are preferred for all machining operations on high explosives. Control mechanisms for hydraulic and pneumatic equipment shall prevent unauthorized personnel from tampering with speeds.

i. In all machining operations on cased or uncased high explosives, procedures during tool adjustments shall prevent contact between moving parts of the machining equipment and metallic parts of the case or holding fixtures.

j. Machining tools shall be compatible with the explosives being processed. Dull or damaged tools shall not be used for machining high explosives.

k. The explosives products resulting from machining operations shall be removed by an exhaust system meeting NEC requirements (reference (j)), or by immersion in a stream of water flowing away from the operation.

l. Machining of explosives of questionable quality during an ammunition and explosives demilitarization process must be accomplished by remote control, with operators protected by operational shields.

6. Assembly and Crimping of Complete Rounds. Each assembly and crimping operation shall be separated from other operations by structures or shielding sufficient to contain any fragments produced.

7. Pressing Explosives

a. Each pelleting operation involving black powder, tetryl, TNT, or other explosives of similar sensitivity; and each operation involving the pressing or reconsolidating of explosives, shall be conducted in a separate room or cubicle having walls of sufficient strength to withstand an explosion of all explosives present.

b. Pressing or reconsolidating explosives in small caliber rounds, tracer bodies, tetryl lead-ins, detonators, and similar items shall be performed on machines having consolidating stations designed to preclude propagation between stations and provide adequate operator protection. Operators must be behind tested protective barriers during such operations.

c. Punches and dies must be in matched sets that have passed inspection. All punches and dies used in explosives pressing operations shall undergo a rigid test, such as a magnaflux or X-ray, before use and regularly thereafter. In a pelleting press, punches and dies must be replaced with matched sets checked and calibrated by a control laboratory.

8. Protection of Primers. Equipment, transportation, and operations shall be designed to protect loose primers or primers in components from accidental impact or pressure. When feasible, a protecting cap shall cover the primer.

9. Explosives Washout and Flashing Facilities. When washout operations are placed in operating buildings or other locations, they shall be separated from other operations by operational shields or proper distances.

a. Ammunition items subjected to washout operations must be subsequently inspected to ensure against residual explosives contamination. When contamination is confirmed, decontamination must precede disposal. Decontamination of ammunition items by flashing (exposure to flame) will be performed at the explosives destruction (burning) area or in approved incinerators.

10. Heat Sealing Equipment. Electric heat sealing machines should be separated from other operations. Temperature limits for heat sealing equipment shall be established, with a safety factor below the ignition temperature of the explosives, propellants, or pyrotechnics involved.

11. Rebowling Operations. Rebowling operations involving lead azide and primer mixes shall be performed by remote control, with the operator protected by an operational shield.

12. Thread Cleaning

a. Nonferrous picks shall be used for thread cleaning. Stainless steel brushes may be used to clean threads of explosives-loaded projectiles if a fuze seat liner separates the thread cleaning operation from the explosive charge. Operators do not need operational shields; however, thread cleaning operations should be separated from unrelated operations.

b. Power-actuated thread-chasing tools may be used to clean loaded projectiles when threads are imperfect because of previously applied sealers, provided the operation is performed within a separate cubicle and by remote control. Hand-operated thread-chasing tools may be used when no explosives are present in the threads.

c. Neither correcting cross threads nor thread cutting shall be performed on projectiles containing explosives. Straightening crossed threads is considered thread cutting.

13. Profile and Alignment Gaging Operations

a. Operational shields shall enclose each profile and alignment gaging operation, excluding small arms ammunition, to protect adjacent operations. The layout of the equipment and the operational procedures will be developed to minimize personnel injury and property damage in case of accident.

b. During chamber gaging of high caliber fixed ammunition, the gage should be pointed toward a dividing wall or other barrier and the round inserted and removed by the same operator. In no case will the round be left in the gage. Rounds of mortar ammunition shall be gaged before attaching propellant increments and, unless prohibited by the design characteristics, before assembly of the ignition system.

14. Spacing of Units Containing Explosives on Conveyors. Containers of explosives and explosives-loaded items in operating lines that are being moved on conveyors shall be separated from each other by sufficient distance or provided equivalent protection against propagation. Periodic cleaning shall keep conveyors free of explosives dust and scrap, preventing propagation along the conveyor.

CHAPTER 14

TESTING STANDARDS

A. GENERAL

The safety standards of this chapter supplement others in this Manual. Because setting safety standards for land, air, and sea test areas is site-dependent, involving case-by-case evaluation of danger areas and range firing layouts, the subject will not be discussed here. When contracts do not address relevant safety standards, the contractor shall request them from appropriate Federal, state, or local authorities, or the contracting officer.

B. PROGRAM REQUIREMENTS

The contractor is responsible for the safety of testing programs and will designate an individual to be responsible for each program. Technical information about the ammunition items, explosives, and weapon systems shall be considered so that the required safety measures may be engineered into the test plans.

C. OPERATING PRECAUTIONS

Special safety precautions to be considered during SOP development:

1. Protection against accidental initiation shall be provided in the design of equipment, transportation, and operations involving percussion elements, that is, primers, caps, etc.

2. Cartridges and projectiles larger than 60mm, when hand carried, shall be handled one at a time.

3. Fuzed projectiles must not be handled by the fuzes alone.

4. Powder charges shall be transported in closed containers to prevent accidental ignition.

5. Only trained personnel shall perform operations on explosives-loaded ammunition components.

6. No work, adjustment, or observation should be permitted on a weapon system that is loaded and ready for firing, except to check and adjust azimuth and elevation. In no case shall a lanyard be attached until the piece is ready to be fired. No one shall step over the lanyard once it is attached. Safety locks may be released after the lanyard has been attached. The bolt shall be kept open at all times except when actually firing small arms.

7. With the exception of inert components, A&E material shall be delivered only to machine shops or other specifically designated locations, unless responsible contractor personnel authorize other arrangements.

8. Training shall preclude the premature or improper mixing of fuels and oxidizers associated with liquid propellants.

9. Remote control of mechanical devices shall replace manual activation whenever possible.

10. Devices permitting operators to cease firing when conditions turn hazardous shall equip guns operated by remote control. These devices shall be independent of the regular controls, for use as backup.

D. TEST HAZARDS

1. Inert-loaded or minimum-charged ammunition shall replace explosives-loaded items when test objectives will not be affected.

2. When temperature-conditioning rooms or boxes are utilized, the following shall apply:

a. Firings from temperature-controlled facilities shall be on an azimuth approved by the contractor's responsible representative. No weapon shall be fired in an enclosed area unless the muzzle is located outside the port opening. Destruction tests, excess pressure tests, and tests of classes of guns known to be unsafe (where the possibility of breech failures exists), shall be conducted with portable shields or equivalents placed on each side of the breech and with a protective plate to the rear of the mount, forming a barrier.

b. All equipment used in the temperature conditioning of explosives shall comply with Q/D requirements, unless in explosives buildings.

c. Dual automatic controls shall regulate temperatures in conditioning equipment and rooms using heat.

3. No firing shall be permitted unless people in the area are under adequate cover.

E. TEST CLEARANCE

1. Clearance, to be obtained before performing each test, shall be granted only by responsible contractor personnel with jurisdiction in the danger area where the test is to be performed. When required, air space clearances shall be be obtained in accordance with local and FAA Handbook (reference (k)) requirements.

2. The contractor personnel responsible for the test areas where the weapon system is located shall obtain the necessary coordination and clearance from their counterparts when a test may encroach upon other danger areas.

3. To ensure that danger areas are clear of personnel and ships, vessels, and other craft, clearance for impact and airburst danger areas shall be obtained before firing on or over water.

F. WARNING AND COMMUNICATION SYSTEMS

A warning system shall be established for each testing program, comprising some combination of flags, lights, and sound signals. If personnel authorized

to enter a test area do not know its warning system, they must be escorted by knowledgeable personnel. Test areas should be equipped with adequate communication facilities, such as telephone and radio.

G. SPECIFIC ITEMS FOR TEST

The safety standards required for testing specific items of ammunition vary according to the type of ammunition, design features, explosives characteristics, test facilities, climate and terrain environment, and other related factors. The test plan must consider these factors and include specific test criteria in accordance with the contract.

1. Recoilless Weapons

a. All personnel shall be protected against breech blast and malfunction of the round. The danger area in open range firing shall extend to the rear of the weapon: 300 feet for calibers up to and including 75mm and 450 feet for all others. The danger zone may be reduced only when effective barricades confine the blast effect.

b. The safety switch on a rifle shall not be advanced to the firing position until the breechblock is closed and all preparations for firing are completed.

c. Because the blast from salvo firing can obscure a misfire, ripple firing is preferred. When salvo firing cannot be avoided, a wait of a least 2 minutes shall precede the opening of any breechblock after a one-volley salvo.

d. Unburned propellant from any test firing must not accumulate in the surrounding area. Safe methods shall be developed for cleanup, decontamination, and disposal.

2. Pyrotechnics. Shielded enclosures should be used when testing pyrotechnic items inside a building. Enclosures should be vented to the outside, preferably through the roof, to prevent exposure of personnel to flame, toxic gases, and heat, and to prevent rupture of the enclosures.

3. Static Tests of Propellant Motors and Engines. Static test stands are used for solid propellant motors and liquid propellant engines in any combinations. Fire, blast, and fragments shall be considered in establishing safety distances. In addition, firing structures will contain and restrain from movement motors and engines undergoing tests.

H. MALFUNCTIONS

For the purposes of this Manual, malfunction applies to the ammunition and the weapon systems or pieces involved.

1. Cook-off. Automatic function, or cook-off, of a round left in a hot gun for an extended period is possible in tests involving a high rate of fire, particularly with machineguns and antiaircraft guns. This possibility largely depends upon the gun's rate of heat dissipation, but high air temperature, low wind velocity, low elevation of the gun, and confinement of the gun are also factors. To prevent cook-off, the barrel of the empty gun shall be frequently

cooled. If a round is retained or remains in a hot gun with the breech closed, people in the vicinity shall remain under cover until the gun has cooled. If a round jams and the breech fails to close, personnel in the danger zone shall take cover and remain there until the gun has cooled.

a. Adequate cooling periods are:

Type of Cooling	Time (minutes)
Water	5
Air (machine guns)	15
Air (other guns)	30

b. The danger zone for personnel in the vicinity of the gun firing explosive ammunition shall be:

Type of Gun	Radius* (feet)
Machineguns	600
Less than or equal to 75mm	1,200
Over 75mm through 105mm	1,800
Over 105mm	2,400

c. The danger zone down range shall be maintained as for actual firing until the danger of cook-off has passed.

2. Premature Burst. If a premature burst occurs, the test shall be suspended or the lateral limits of the danger zone increased in accordance with prescribed safety distances before the test continues. The increased lateral limits shall be maintained until the particular test is completed.

3. Misfires. All persons waiting after a misfire shall stand clear of the breech, in case the round functions and the gun recoils. All electrical connections that could cause firing of the gun shall be disconnected. The appropriate danger zone for the actual firing shall be maintained during the waiting period, until the danger of cook-off has passed. The removed round shall be immediately placed where subsequent detonation could not cause injury or damage. In the case of misfires involving small-caliber rockets and small-arms ammunition, the rounds should be immersed in water. Misfire procedures for all weapon systems shall cover attempts to refire weapons, waiting periods, cooling, operational precautions, and disposition of ammunition. Once these procedures have been carried out, the firing pin and mechanism shall be checked, and the barrel of the gun examined to ensure that it is clear. Then firing may resume. Figures 14-1 through 14-8 provide general guidance on what to do when misfires occur.

4. Hangfires. A hangfire is a delayed firing occuring as a short timelag between the striking of the firing pin on the primer and the ignition of the

*Radii may be halved when inert ammunition is used. The use of barricades to confine blast effects may also reduce the danger zone.

primer, igniter, or propellant. All hangfires shall be immediately reported to responsible personnel. This is particularly important for early detection of trends. In these cases, the firing of a particular lot of ammunition shall be suspended unless responsible authorities advise differently.

I. AMMUNITION AND DUD RECOVERY

Open-air test area recovery standards follow:

1. Marking. When projectiles or bombs with live fuzes, live boosters, or high explosive are fired for impact on, or burst over, a recovery field, observers stationed in a protected place shall record the location of duds and exploded rounds. Before leaving a recovery field or impact area, personnel in charge of cleaning the fields shall mark duds and exploded rounds with the appropriate color-coded flag or device. Where locations cannot be marked, fields shall be posted with warning signs and entry shall be restricted.

2. Policing. Personnel shall be prohibited from touching or in any way disturbing dud ammunition. Unfuzed or inert-fuzed live ammunition or ammunition components that have failed to function during a test shall be recovered only in accordance with the SOP developed by the contractor.

3. Destruction. All types of ammunition and explosives shall be disposed of in accordance with this Manual, contract requirements, or instructions provided by the contracting officer (in order of increasing priority).

J. PERSONNEL SHELTERS

1. General. Responsible personnel shall require all within the danger zone to take cover during tests where fragmentation might occur. The person charged with attaching the lanyard shall be the last to leave the gun emplacement, and shall advise the responsible person that all personnel are clear before any firing.

2. Portable Bombproofs. Structures found satisfactory for the protection of personnel within the danger zones of firing follow (see paragraph J.3., below).

3. Portable Bombproofs for Fire Observation. All portable bombproofs used for fire observation shall be on the gun side of the impact point; no closer than 200 yards from the impact point; and in the sectors between compass headings 45 and 80 degrees and between 280 and 315 degrees (compass centered on impact point with 0 and 360 degrees at the firing point). When the impact will result in fragmentation, the bombproof should be located behind the firing line in the sectors between compass headings 100 and 135 degrees and between 225 and 260 degrees (compass centered on firing point with 0 and 360 degrees at the impact point). It should be so oriented with respect to the impact that no wall surface is presented to fragmentation at an angle greater than 60 degrees. This can usually be done by centering one intersection of the walls of a square of U type bombproof, or pointing the apex of a pointed V type, toward the impact point. Under no circumstances shall the orientation expose the rear of the bombproof to gunfire and fragmentation. Observations from bombproofs shall be indirect, using mirrors, periscopes, or other suitable devices.

Type	Location and Use	Wall
Portable reinforced concrete bombproof (open back).[1]	At firing fronts when alongside or to rear of gun and offset from line of fire for any class of fire.	12 inches
Armored railway mounts.	At firing fronts when alongside or to rear of gun and offset from line of fire for any class of fire.	armorplate
Portable boiler-plate barrier.	At firing fronts for inert shrapnel or low explosive up to and including 155mm and all small-arms ammunition.	3/4-inch steel plate
Portable armor-plate barrier.	At firing fronts when to rear and offset from line of fire for any classes except high explosive or plate firing.	3-inch armorplate
Armorplate sheets.	At firing fronts for grenades, primer detonators, and ground troop signals.	1/2-inch armorplate

K. TESTING OF AMMUNITION OR DEVICES FOR SMALL ARMS

1. Ammunition shall not be placed in any gun until it is in firing position and ready to shoot.

2. Safety devices on gun mounts and ranges shall be kept in operating condition and tested before use. If a malfunction occurs, test operations shall cease and a report made to the responsible supervisors.

3. Every weapon removed from a firing position, storage case, or rack; or picked up by any operator, shall be inspected for the presence of ammunition in the chamber, magazine, or feed mechanism, and for obstruction in the bore.

4. The chamber, magazine, and feed mechanism of all guns should be open during handling and transportation. When practicable, a safety block should be used in the chambers of weapons.

5. Primers of misfired rounds may be hypersensitive; precautions should be taken during their removal from the gun, handling, and disposal.

6. Firing on ballistic ranges, except in function and casualty tests, shall be from fixed rests.

[1] This type may be used for fire observation in the field, provided the bombproof is offset from the line depending upon the caliber of guns used, and in accordance with paragraph J.3., above.

7. When sand butts are used to stop bullets, a reinforced concrete wall should be constructed at sufficient distance behind the retaining wall to permit inspection. This is necessary because bullets tend to tunnel through the sand and penetrate the retaining wall after continued firing. To discover any such penetration, the inner face of the second wall should be inspected frequently. If terrain effectively protects the rear of the range, no concrete wall is necessary.

8. Because bullets tend to ricochet from a sand bank, the roofs of enclosed ranges should be protected, to prevent penetration.

9. When water traps are used to receive a fired bullet, interlocks shall be provided to prevent firing of the test weapon if water pressure failure occurs.

10. Unburnt powder and propellant grains shall be cleaned and disposed of, as necessary.

L. VELOCITY AND PRESSURE TESTS

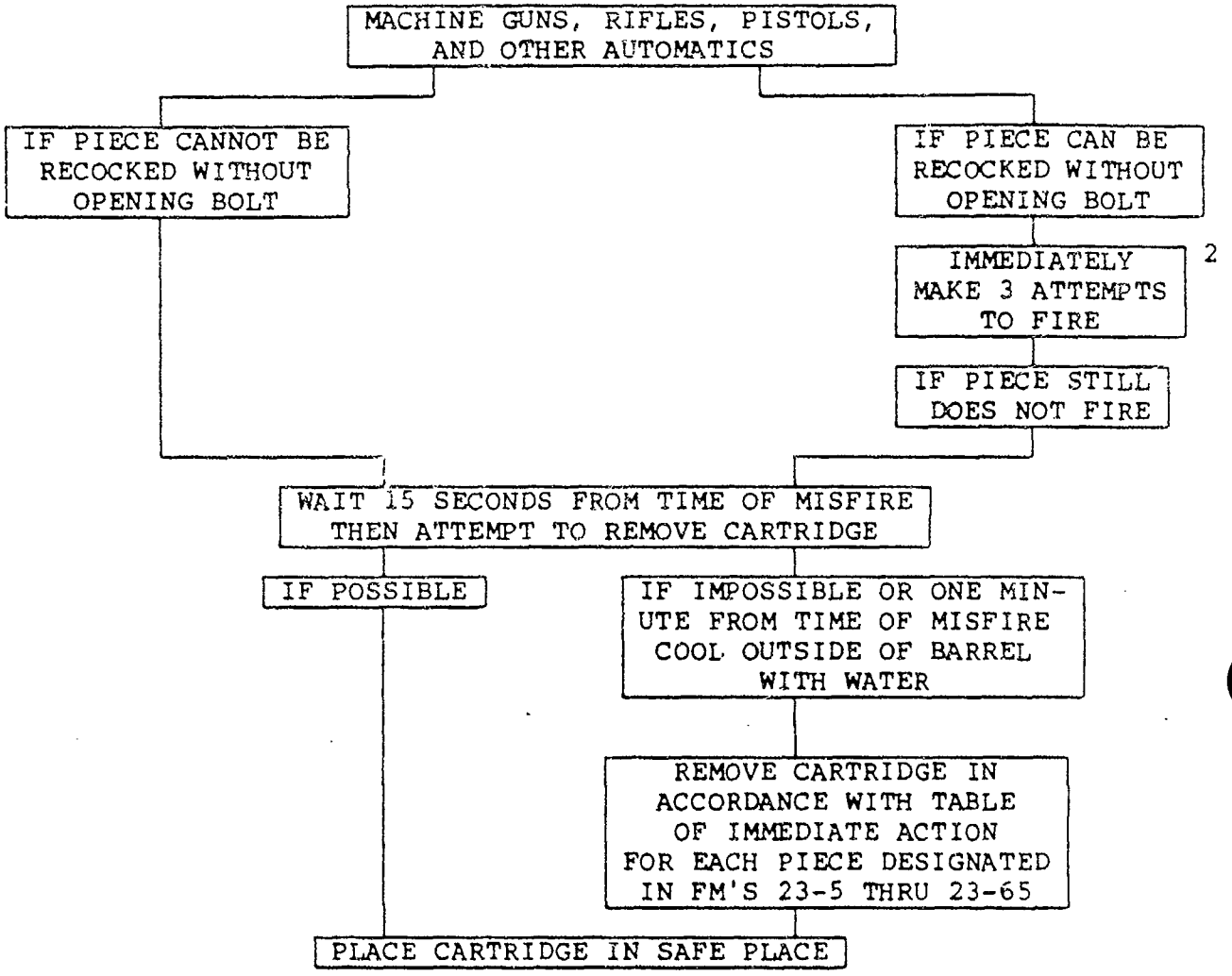
Special high pressure tests or tests of unknown pressure ammunition shall be performed only when personnel are protected against injury from gun failures. Operational shields or remote control firing of guns serves this purpose.

M. PRIMER DROP TESTS

1. Cases containing live primers shall be marked and separated from those containing fired primers.

2. The collecting tube and areas where primer dust could accumulate shall be regularly inspected and cleaned.

MISFIRE OF MACHINE GUNS, RIFLES, PISTOLS, AND OTHER AUTOMATICS[1]



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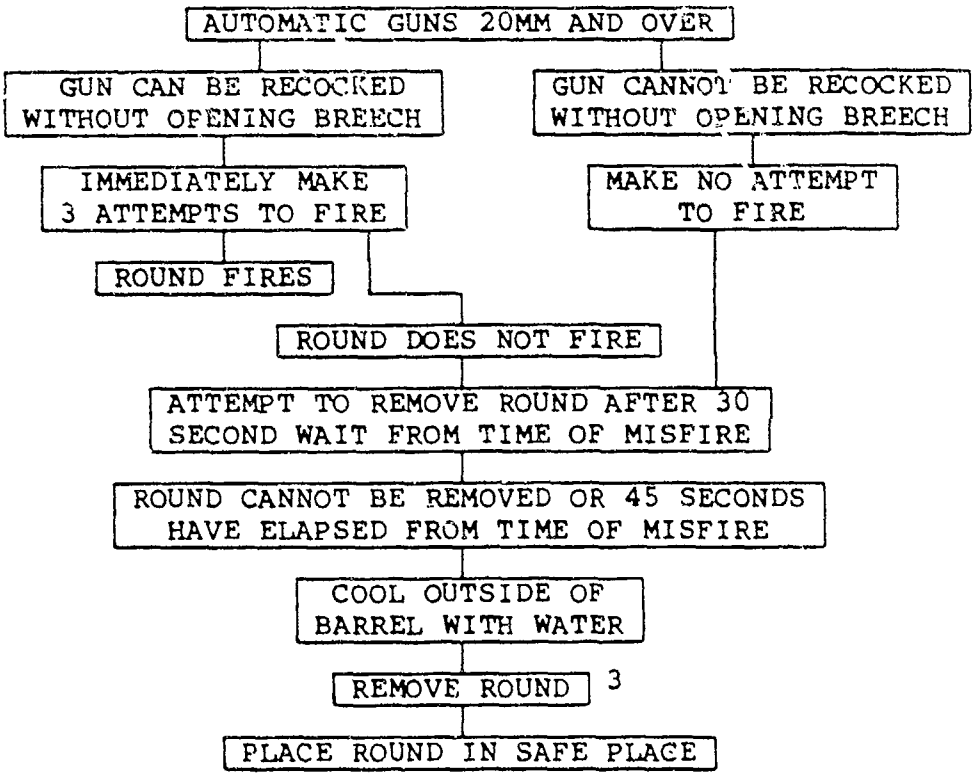
[1]For misfire of machine guns wherein no possibility of automatic cook-off exists.

[2]To avoid injury in case of hangfire, make sure that no part of either hand or wrist can be struck by the operating slide should it suddenly move to the rear.

FIGURE 14-1. Misfire of Machine Guns, Rifles, Pistols, and Other Automatics.

MISFIRE OF AUTOMATIC GUNS 20MM AND OVER[1,2]



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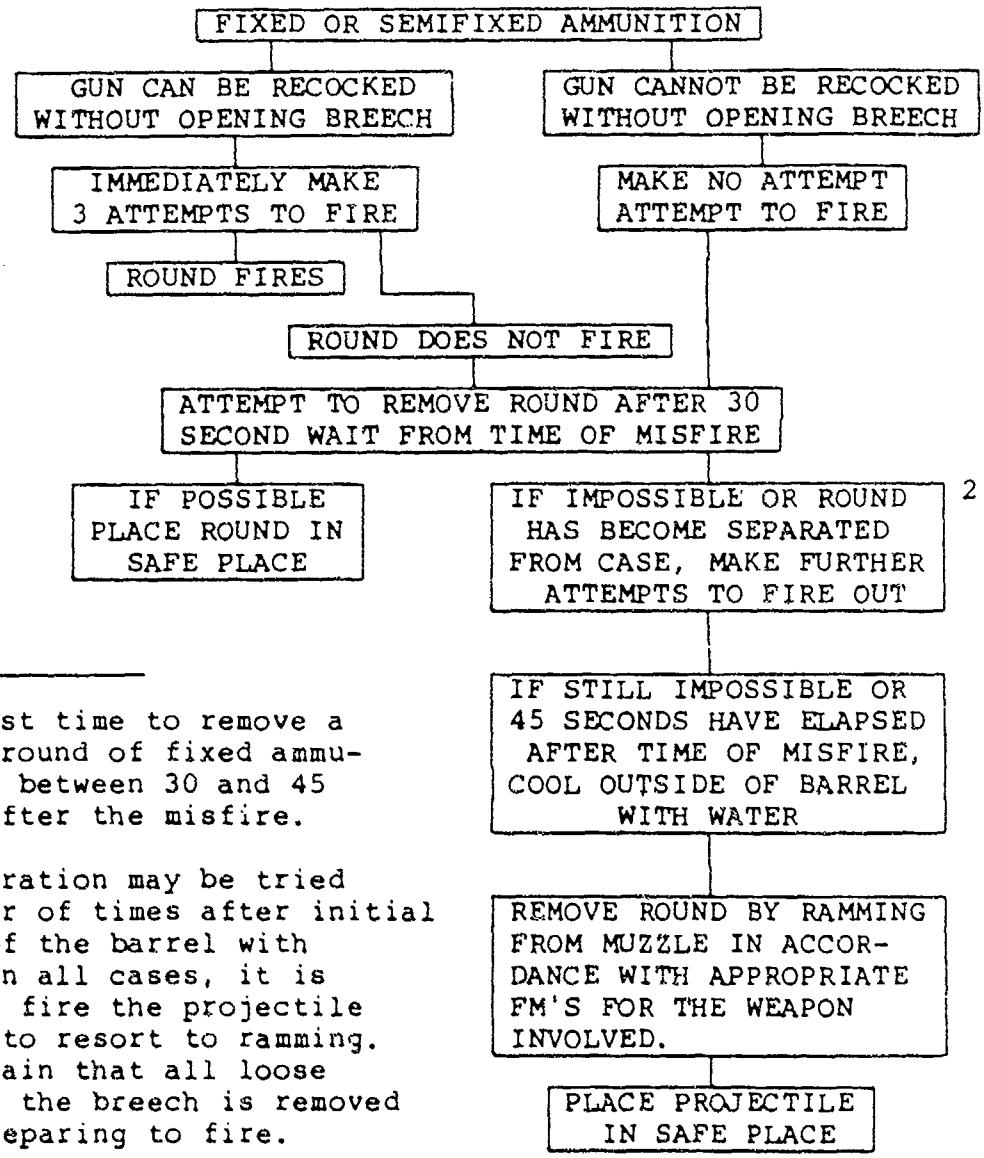
[1]The safest time to remove a misfired round of fired ammunition is between 30 and 45 seconds after its occurrence.

[2]Wherein no possibility of automatic function or cook-off exists.

[3]If round separates, follow procedures shown in Fig. 14-3.

Figure 14-2. Misfire of Automatic Guns, 20mm and Over.

MISFIRE OF FIXED OR SEMIFIXED AMMUNITION[1]

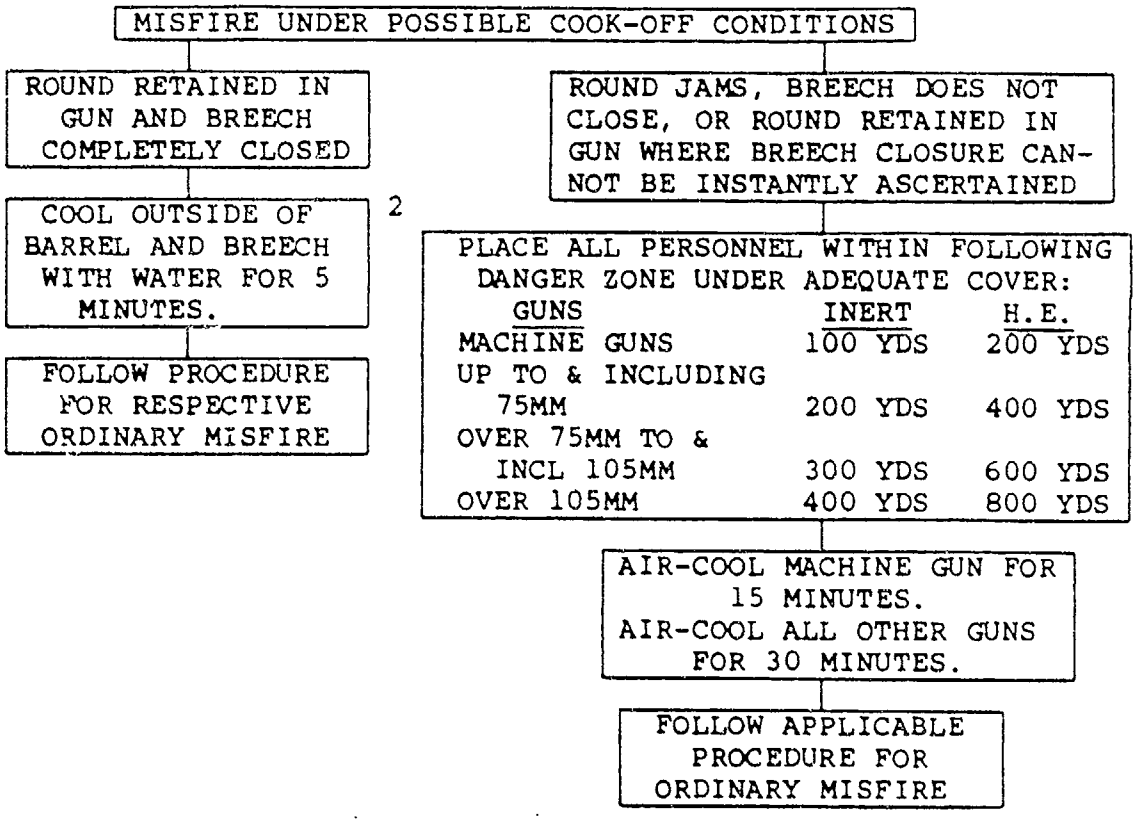


[1]The safest time to remove a misfired round of fixed ammunition is between 30 and 45 seconds after the misfire.

[2]This operation may be tried any number of times after initial cooling of the barrel with water. In all cases, it is better to fire the projectile out than to resort to ramming. Make certain that all loose powder in the breech is removed before preparing to fire.

Figure 14-3. Misfire of Fixed or Semifixed Ammunition.

MISFIRE UNDER POSSIBLE COOK-OFF CONDITIONS[1]



[1]For machineguns, antiaircraft guns, or other guns fired at high rates for extended periods.

[2]In tests where water cannot be applied, the danger zone as defined in right column will apply.

Figure 14-4. Misfire under Possible Cook-off Conditions.

MISFIRE OF LEVER- (TRIGGER-) FIRED MORTAR AMMUNITION

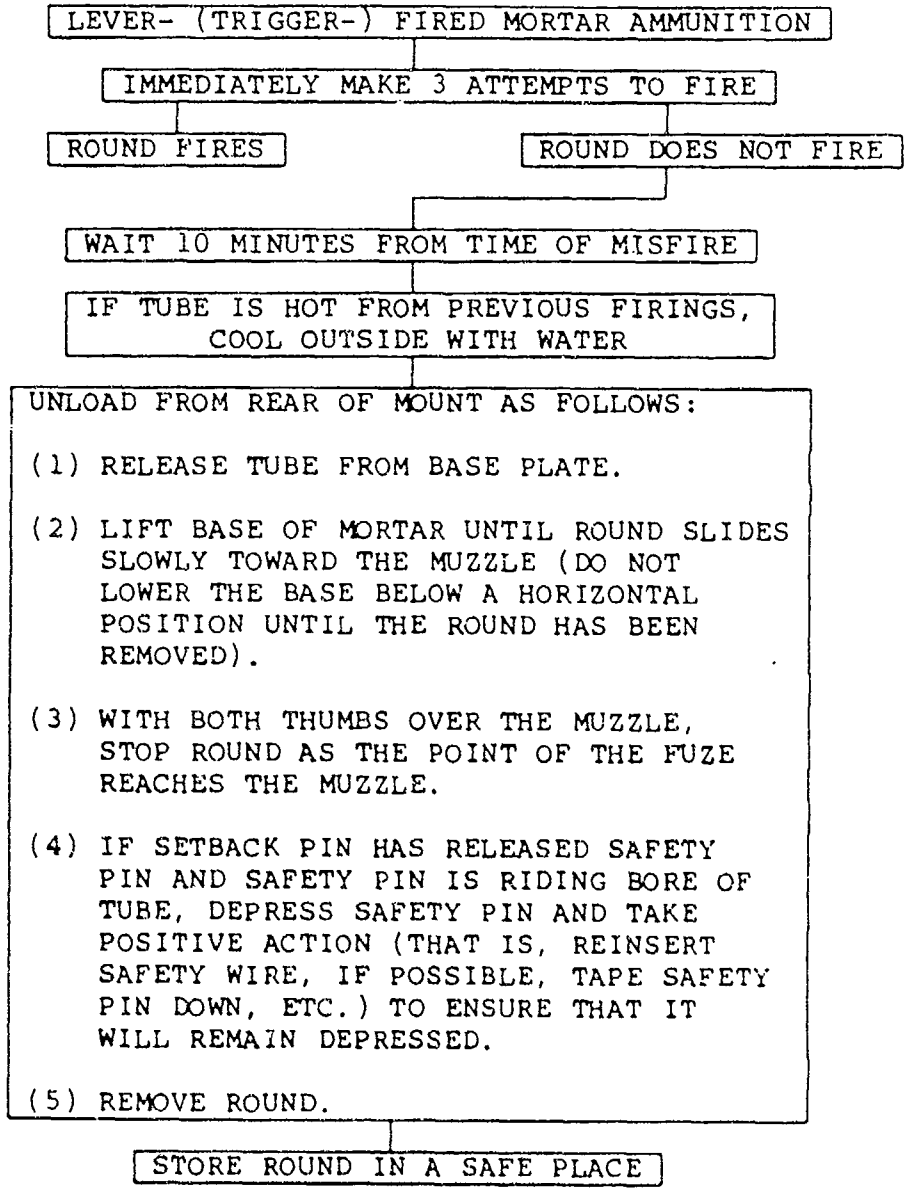


Figure 14-5. Misfire of Lever- (Trigger-) Fired Mortar Ammunition.

MISFIRE OF FIXED FIRING PIN- OR LEVER-TYPE
(SET FOR DROP FIRE) MORTAR AMMUNITION

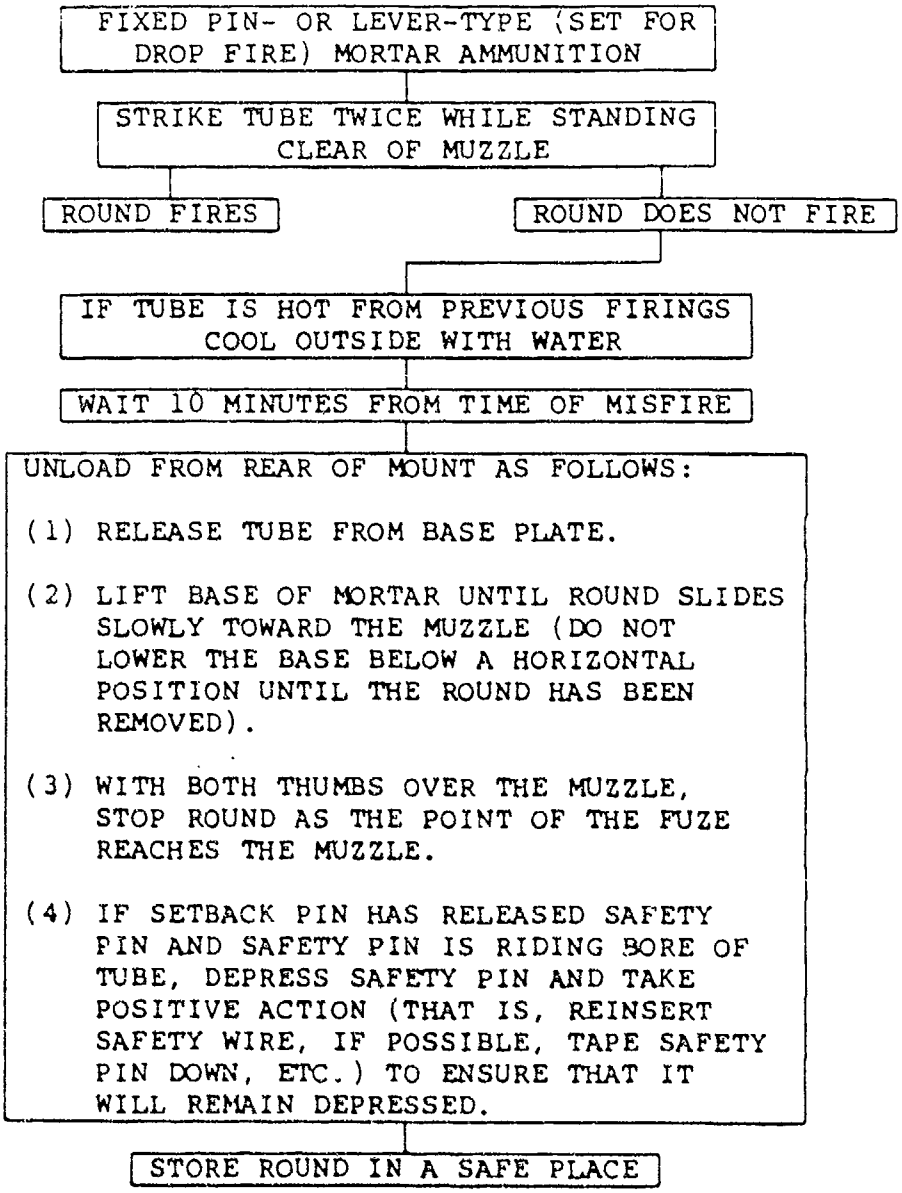
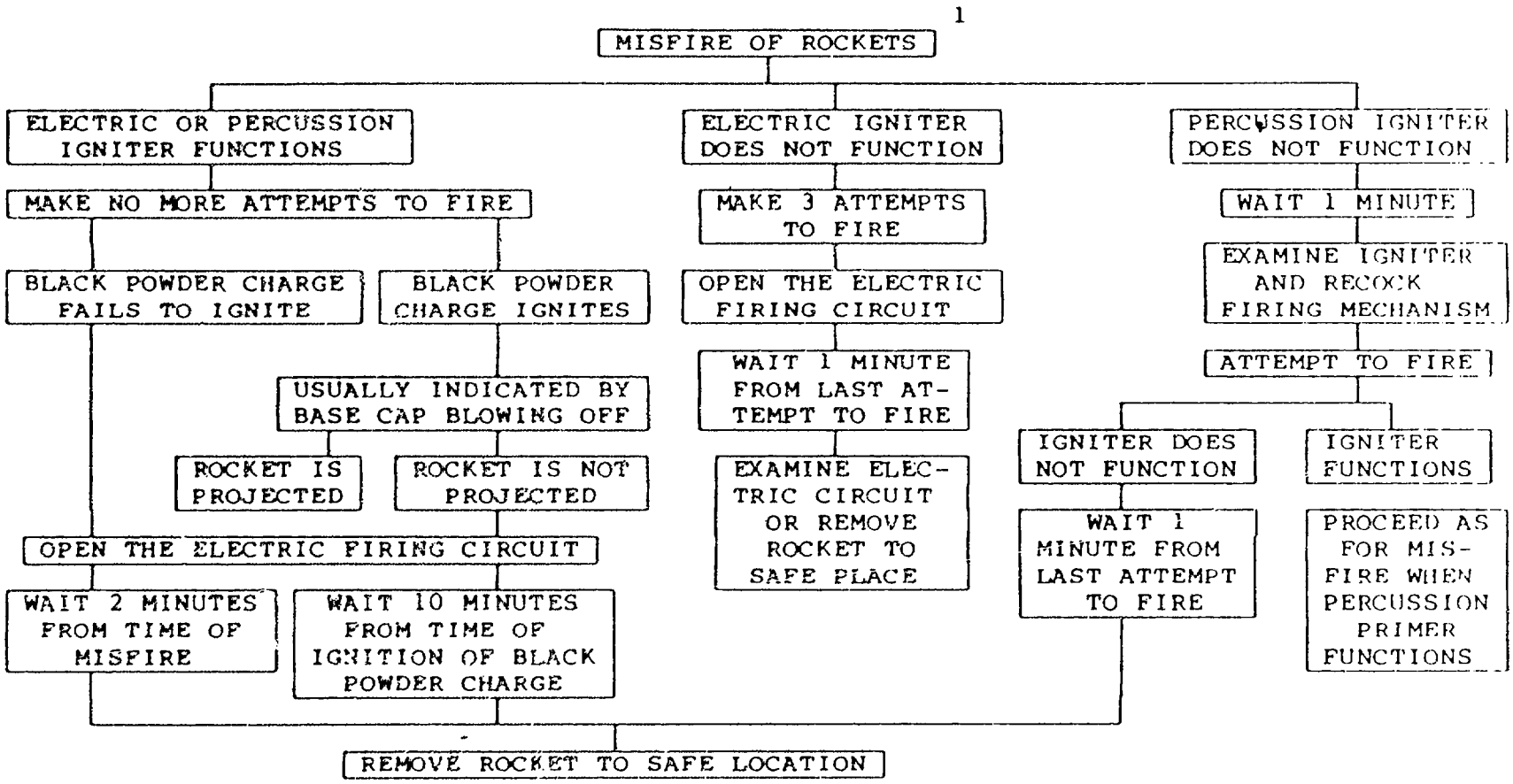


Figure 14-6. Misfire of Fixed Firing Pin- or Lever-Type (Set for Drop Fire) Mortar Ammunition.



[1]For individually fired separate rockets. When firing ripple fire from multiple launchers, all rockets that misfire will be cooled immediately by means of water on exterior of launcher or air-cooled for 30 minutes before removal or inspection. In event there is doubt of igniter functioning after attempting to fire several times using the electric firing circuit, follow procedure as for misfire when electric or percussion igniter functions.

Figure 14-7. Misfire of Rockets.

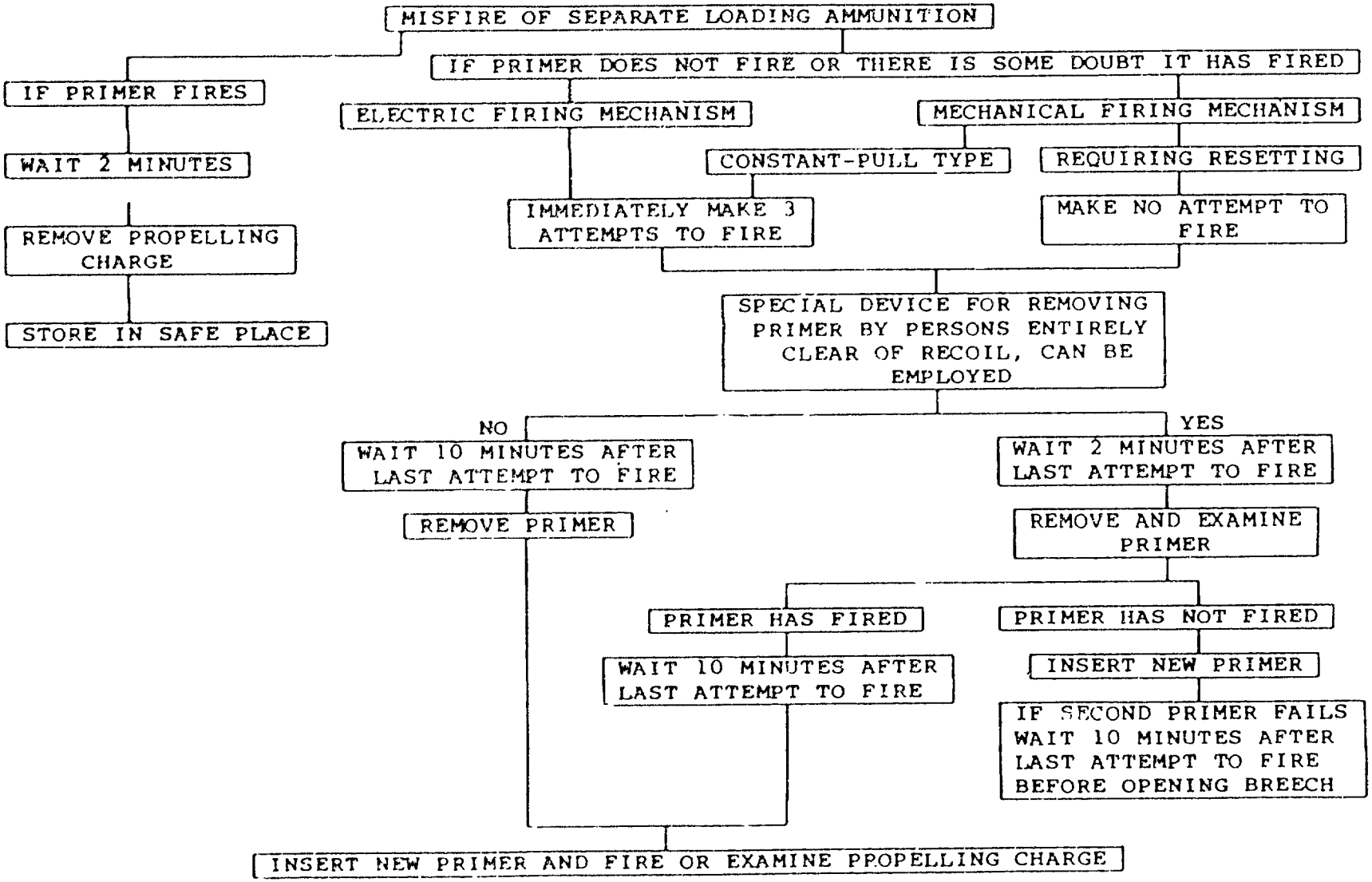


Figure 14-8. Misfire of Separate Loading Ammunition.

CHAPTER 15

COLLECTION AND DESTRUCTION STANDARDS FOR AMMUNITION AND EXPLOSIVES

A. GENERAL

This chapter provides safety standards for the collection and destruction of ammunition and explosives.

B. PROTECTION DURING DISPOSAL OPERATIONS

1. Operational shields and special clothing shall protect personnel in facilities with explosives materials. Fragmentation hazards require, at a minimum, overhead and frontal protection for personnel. Shelters should be located at the inhabited building distance appropriate for the quantity and type of materials being detonated. Personnel shall use such protective measures when destroying explosive materials by detonation and when burning explosive materials that may detonate. Personnel shall not approach the burning site, but shall wait until the fire is out.

2. Personnel shall never work alone during disposal and destruction operations. Warning signs or roadblocks shall restrict the area. One person, available in an emergency, should observe from a safe distance while another performs the operations.

C. COLLECTION OF AMMUNITION AND EXPLOSIVES

1. Water-Soluble Materials. Enough water should be used in neutralizing ammonium picrate (explosive D), black powder, and other soluble materials to ensure their complete dissolution. As little material as practicable should be dissolved at one time. Sweeping floors before washing them down reduces the amount of dissolved material in the wash water. When uncertainty exists concerning the purity and composition of wash water, experts shall be consulted.

2. Solid Wastes. Explosives-contaminated solid waste material shall be collected; placed in closed containers; and swiftly removed to buildings for treatment or holding, or to the burning ground for destruction.

3. Explosives Dusts

a. High explosives dusts such as TNT, tetryl, explosive D, composition B, and pentolite should be removed by a vacuum system. A "wet collector" that moistens the dust near the point of intake and keeps it wet until the dust is removed for disposal is preferred for all but explosive D, which should be collected in a dry system.

b. More sensitive explosives such as black powder, lead azide, mercury fulminate, tracer, igniter, incendiary compositions, and pyrotechnic materials may be collected by vacuum, provided they are kept wet close to the point of intake. Collect each type, representing a different hazard, separately, so that black powder, for example, cannot mix with lead azide. Provision should be made for releasing any gases that form. The use of vacuum systems for collecting these more sensitive materials should be confined to operations involving small quantities of explosives, that is, operations with fuzes,

detonators, small-arms ammunition, and black powder igniters. To minimize the fire and explosion hazard, collection of scrap pyrotechnic, tracer, flare, and similar mixtures in No. 10 mineral motor oil or equivalent is required. Materials collected in the dry state shall be placed in an oil-containing receptacle, either a catch pan or scrap-transportating container, available at each operation throughout the shift. The oil level should be about 1 inch above the level of any pyrotechnic mixture in the container. Containers or buckets, made of heavy oil-resistant cardboard, shall be removed from the operating buildings for burning at least once per shift. Appropriately rated class B firefighting equipment shall be available when oil is used.

4. Design and Operation of Collection Systems

a. Collection systems and chambers shall be designed to prevent pinching thin layers of explosives or explosives dust between metal parts. Pipes or ducts used to convey dusts require flanged, welded, or rubber connections. Threaded connections are prohibited. The system shall prevent explosives dusts from accumulating in parts outside the collection chamber. Pipes or ducts conveying high explosives shall have long radius bends. Systems for propellent powder may use short radius bends provided they are stainless steel, with polished interiors. Vacuum application points should be kept to a minimum. Each room requiring vacuum collection should have a separate exhaust line to the primary collection chamber; if this is not possible, no more than two bays shall be serviced by a common header. Wet primary collectors are preferred. The length of vacuum line from points of application of vacuum to the wet collectors should be short. A single secondary collector shall service as few primary collectors as possible. Not more than two dry primary collectors shall be connected to a single secondary collector (wet or dry type). If an operation does not create a dust concentration potentially posing a severe health hazard, manual operation of the suction hose to remove explosives dust is preferred, since permanent attachment to the explosive dust-producing machine increases the likelihood of propagation through the collection system of a detonation at the machine. Manually operated hose connections to explosives dust-producing machines should not interconnect.

b. Two collection chambers serially installed ahead of the pump or exhauster prevent explosives dust from entering the vacuum producer in a dry vacuum collection system.

c. Slide valves for vacuum collection systems are permitted. An aluminum slide operating between two ebonite spacer bars or similar, compatible materials will eliminate unacceptable metal-to-metal contact.

d. Dry-type portable vacuum collectors, limited to five pound of explosives, will be located in a separate cubicle having substantial dividing walls, or outside the building; never in a bay or cubicle with explosives. Wet-type portable vacuum collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collector is limited in accordance with the requirements of paragraphs C.5.a. through c., below. For dry collection of quantities in excess of five pounds or wet collection of quantities in excess of 15 pounds, the provisions of paragraphs C.5.a. through c., below, also apply.

e. The design of wet collectors shall provide for proper immersion of explosives, breaking up air bubbles to release airborne particles; and for removal of moisture from the air leaving the collector, to prevent moistened particles of explosives from entering the small piping between the collector and the exhauster or pump.

f. At least once every shift, explosives dust shall be removed from the collection chamber to eliminate unnecessary and hazardous concentrations of explosives. The entire system should be cleaned weekly, with parts dismantled as necessary.

g. The entire explosives dust collecting system shall be electrically grounded. The grounding shall be tested frequently.

h. Small vacuum systems positioned close to work stations shall be shielded.

5. Location of Collection Chambers

a. Whenever practicable, dry-type explosives dust collection chambers, except portable units, shall be located in the open, outside operating buildings, or in buildings set aside for the purpose. To protect operating personnel from blast and fragments from the collection chamber, a barricade or operational shield appropriate for the hazardous quantities involved, shall be provided between the operating building and the outside location or separate building housing the collection chamber. At least 3 feet shall separate the collection chamber from the barrier wall.

b. When locating dry-type collection chambers outside the operating building is not feasible, a separate room shall be set aside for this purpose in the building. This room shall neither contain other operations nor be used as a communicating corridor or passageway between other operating locations when explosives are being collected. Walls separating the room from other portions of the operating building shall meet the requirements for operational shields for the quantity of explosives in the collection chamber. If more than one collection chamber is to be located in the room, the room shall be subdivided into cubicles, with only one collection chamber per cubicle.

c. Stationary and portable wet-type collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collectors does not exceed five pounds. Placed in separate cubicles, quantities may increase to 15 pounds. For wet collectors containing more than 15 pounds, location requirements set forth in paragraphs C.5.a. and b., above, apply.

6. Explosives/Munitions Awaiting Destruction. Material awaiting destruction when stored in the open shall be inhabited building distance from explosives being destroyed. Provided with adequate frontal and overhead protection, material awaiting destruction may be stored at intraline distance from the explosives being destroyed. All such material shall be protected against accidental ignition or explosion from ambient storage conditions or from fragments, grass fires, burning embers, or blast originating in materials being destroyed.

7. Containers for Waste Explosives. Containers for these explosives shall be the original closed packages or equivalent. Closures shall prevent spillage or leakage of contents when handled or overturned, and must not pinch or rub explosives during closing and opening. Directions shall be clearly marked. No containers constructed from spark-producing or easily ignited material shall be used.

D. DESTRUCTION SITES

1. Site Criteria

a. Destruction of ammunition and explosives shall occur as far as possible from magazines, inhabited buildings, public highways, runways, taxiways, and operating buildings. Separation distances shall be at least 2,400 feet unless pits or similar aids limit the range of fragments, in which case the appropriate fragment distance shall apply. Natural barricades shall be used between the site and operating buildings or magazines. The possibility that the explosives may detonate when being burned requires use of appropriate protective barriers or separation distances for the safety of personnel and property. Explosives shall not be burned or detonated on concrete, nor in areas having large stones or crevices.

b. In all disposal and destruction activities, the number of A&E units or the explosives quantity that may be safely destroyed at one time can be determined by gradually increasing a limited number of items or quantity until an explosion reveals the amount consistent with safe and efficient operations.

c. Firefighting equipment should be available to extinguish grass fires and to wet down the area between burnings and at the close of operations.

d. Ordinary combustible rubbish should not be disposed of near areas where explosives and explosives-contaminated material are destroyed.

2. Material and Equipment Usage

a. Detonation of ammunition or explosives should be initiated by electric blasting caps, using blasting machines or permanently installed electric circuits energized by storage batteries or conventional power lines. When items to be detonated are covered with earth, the initiating explosives should be primed with enough primacord to allow connecting the blasting cap above ground level.

b. Special requirements for using electric blasting caps and electric blasting circuits follow.

(1) The shunt will not be removed from the lead wires of the blasting cap until the moment of connection to the blasting circuit. If the shunt must be removed to test the blasting cap before priming the charge, short circuit the lead wires again following the test by twisting the bare ends of the wires together. The wires will remain short circuited in this manner until the moment of connection to the blasting circuit.

(2) When uncoiling the leads of blasting caps, the following shall apply:

(a) No one shall hold the cap at its explosives end.

(b) The explosives end of a hand-held cap should be pointed down, away from the body, to the rear.

(c) The wires shall be held carefully so that there is no tension where it connects to the cap.

(3) The lead wires of electric caps shall be straightened as necessary by hand. These wires must not be thrown, waved through the air, or uncoiled by snapping as a whip.

(4) Firing wires shall be twisted pairs. The connection between blasting caps and the circuit firing wires must not be made unless the power ends of the circuit leads (firing wire) are shorted and grounded.

(5) Electric blasting or demolition operations and unshielded electric blasting caps shall be at safe distances from radio frequency energy transmitters.

(6) The blasting circuit shall be tested for extraneous electricity before electric blasting caps are connected to firing wires. To do so, arrange a dummy test circuit similar to the actual blasting circuit except that a radio pilot lamp of known good quality, using no electricity, shall substitute for the blasting cap. If this pilot lamp glows in the dark, indicating possibly dangerous amounts of RF energy, blasting operations shall proceed with non-electric blasting caps and safety fuses. Other instruments, such as the DuPont "Detect-A-Meter" or "Voltohmeter," may be substituted for the radio pilot lamp used in testing.

(7) If the exposure is to radar, television, or other microwave transmitters, the actual blasting circuit, with blasting cap included but without other explosives, shall be used to test for extraneous electricity. Personnel performing such tests must be protected from the effects of an exploding blasting cap.

(8) Blasting and demolition operations shall be suspended during electrical storms, approaching as well as in progress. At first sign of an electrical storm, cap wires and lead wires shall be short-circuited, and all personnel removed from the demolition area to a safe location.

(9) A galvanometer shall test the firing circuit for electrical continuity before it connects with the blasting machine. Before completing the circuit at the blasting machine or panel and signaling for detonation, the individual assigned to make the connections must confirm that everyone in the vicinity is in a safe place. This individual shall not leave the blasting machine or its actuating device for any reason and, when using a panel, shall lock the switch in the open position until ready to fire, retaining the only key.

(10) When transported by vehicles with two-way radios, and when in areas presumed to have extraneous electricity, blasting caps shall be in closed metal boxes.

c. When hazards described in paragraph D.2.b.(1), above, prevent the use of electrical initiators for detonation, safety fuses shall be used. At the beginning of each day's operation and whenever a new coil is used, the safety fuse's burning rate must be tested. The fuse shall be long enough for personnel to retire to a safe distance. Under no circumstances shall the fuse length be less than that required for a 2-minute burning time. Approved crimpers shall be used to fix fuses to detonators. Only fuses small enough in diameter to enter the blasting cap without forcing shall be used. All personnel except the fuse-actuator shall retire to the personnel shelter or leave the demolition area before ignition.

3. Servicing of Destruction Site

a. Vehicles transporting explosive material to burning or demolition grounds shall meet the requirements of this Manual. No more than two persons shall ride in the cab. No one shall ride in the truck bed.

b. Vehicles should be unloaded immediately and withdrawn from the burning or demolition area until destruction operations are completed. Containers of explosives must not be opened before the vehicle has departed.

c. Containers of explosives or ammunition items to be destroyed at the destruction site shall be spotted and opened at least 10 feet from each other and from explosive material set out earlier, to prevent rapid transmission of fire if premature ignition should occur.

d. Empty containers shall be closed and removed to prevent charring or damage during burning of explosives. Delivery vehicles on the return trip shall pick up empty containers.

E. DESTRUCTION BY BURNING

1. No mixing of an explosive with extraneous material, other explosives, metal powders, detonators, or similar items shall occur without authorization.

2. Because of the danger of detonation, ammunition and explosives shall not be burned in containers or in large masses, except as directed by competent contractor authority.

3. Beds for burning explosives shall be no more than 3 inches deep. Wet explosives may require a thick bed of readily combustible material underneath and beyond to ensure that all the explosives will be consumed upon ignition. An ignition train of combustible material leading to the explosives shall be arranged so that both it and the explosives burn against the wind. When wind velocity exceeds 15 miles per hour, no disposal by burning shall take place. For direct ignition of a combustible train, either a safety fuse long enough to permit personnel to reach protective shelter or a black powder squib initiated by an electric current controlled from a distance or protective structure, shall be used. Tying two or more squibs together may be necessary to ensure ignition of the combustible train. Combustible materials are not needed for burning solid propellants ignited by squibs. The sites of misfires shall be evacuated for at least 30 minutes, after which two qualified persons shall approach the position of the explosives: one shall examine the misfire; the

other shall act as backup. Watching the examination from a safe distance, with natural or artificial barriers or other obstructions for protection, the backup shall be prepared to rush to the examiner's aid should an accident occur.

a. Loose, dry explosives may be burned without being placed on combustible material if burning will be complete, leaving the ground uncontaminated. The ground shall be decontaminated often, for the safety of personnel and operations. Volatile flammable liquids must not, at any stage, be poured over explosives or the underlying combustible material to accelerate burning.

b. Wet explosives shall always be burned on beds of nonexplosive materials.

c. RDX should be burned in wet form to prevent detonation.

d. Pyrotechnic materials in oil containers shall be emptied into shallow metal pans before burning. The open containers may be burned with the explosives.

4. Parallel beds of explosives prepared for burning shall be separated by not less than 150 feet. In subsequent burning operations, care shall be taken to prevent material being ignited from smoldering residue or from heat retained in the ground from previous burning operations. Unless a burned-over plot has been saturated with water, then passed a safety inspection, 24 hours must elapse before the next burning.

5. Some explosives and tracer or igniter compositions give off toxic fumes when being destroyed by burning. Personnel exposed to such fumes shall wear protective respiratory equipment, such as hose masks, airline masks, or self-contained breathing apparatus.

F. DESTRUCTION BY DETONATION

1. Detonation of ammunition or explosives being destroyed should occur in a pit not less than 4 feet deep and covered with not less than 2 feet of earth. The components should be placed on their sides or in that position exposing the largest area to the influence of initiating explosives. Demolition blocks shall be placed in intimate contact on top of the item to be detonated, secured by earth packed over them. Under certain circumstances, materials such as bangalore torpedoes and bulk high explosives may be substituted for demolition blocks.

2. Local regulations, atmospheric conditions, earth strata, etc., determine how many projectiles and explosives will be destroyed at one time, both in pits and open sites. Taking these variables into account, the acceptable quantity shall be based on criteria in Chapter 4 of this Manual. This procedure should be used for destruction of fragmentation grenades, HE projectiles, mines, mortar shells, bombs, photoflash munitions, and HE rocket heads that have been separated from motors. When a demolition area is remote from inhabited buildings, boundaries, work areas, and storage areas, detonation may be accomplished without the aid of a pit, space permitting.

3. After each detonation, the surrounding area shall be searched for unexploded material and items.

4. In cases of misfires, the procedures in Chapter 14, paragraph H.3., above, shall apply.

G. DESTRUCTION BY NEUTRALIZATION

Certain ammunition and explosives may be disposed of by neutralization. Methods of neutralization include dissolving water-soluble material and chemical decomposition. The contractor, responsible for investigating which of these is most appropriate, must comply with all applicable local, state, and Federal requirements for disposal and contamination operations.

H. DESTRUCTION CHAMBERS AND INCINERATORS

1. General. Small, loaded ammunition components such as primers, fuzes, boosters, detonators, activators, relays, delays, and all types of small-arms ammunition, should be destroyed in destruction chambers and deactivation furnaces. Explosives scrap incinerators should be used for burning tracer and igniter compositions, small quantities of solid propellant, magnesium powder, sump cleanings, absorbent cleaning materials, and similar materials. Destruction chambers and incinerators should be equipped with suitable pollution-control devices, such as multiple chamber incinerators with thermal incinerator afterburners. The final incineration should take place at 1400°F, minimum.

2. Operation of Incinerators

a. The feeding conveyor shall not be operated until the incinerator temperature is high enough to ensure complete destruction. Temperature recording devices should be installed.

b. To remove accumulated residue, incinerators shall be shut down and thoroughly cooled. Repairs shall be made only during shutdown. Personnel entering the incinerator to clean it shall be provided with respiratory protection, to prevent inhalation of toxic dusts or fumes, such as mercury from tracers and lead from small-arms ammunition.

3. Operation of Destruction Chambers and Deactivation Furnaces

a. Operation shall be by remote control.

b. Operators shall not approach the unprotected side of the concrete barricade to replenish fuel, adjust the oil flame, or for any other reason, until enough time has elapsed for explosives in the chamber to go off. To keep the feedpipe chute or conveyor obstruction-free, regular inspections shall take place.

c. Components shall be fed into the chamber a few at a time. The exact number permitted at one time for each type of component shall be posted in a place easily seen from the operator's working position.

d. Guards shall be installed on conveyor-feeding mechanisms to facilitate feeding and to prevent items from jamming or falling.

I. SUPPORT IN DISPOSAL OF WASTE (SDOW)

If Government-owned ammunition items or explosives are declared excess or residual and the contract says nothing about disposition, the contractor must request instructions from the responsible ACO. A contractor having trouble safely disposing of residual (scrap) ammunition items or explosives related to contractual operations may request help from the ACO.

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June 12, 1987

SAFETY MANUAL FOR AMMUNITION AND EXPLOSIVES

The Assistant Secretary of Defense (Force Management and Personnel) has authorized the following changes to DoD 4145.26-M, "Safety Manual for Ammunition and Explosives," March 1986:

PEN CHANGES

Page vii, Table 6-17. Add "for airfields".
Page viii, definition 4., line 3. Delete "chemical agents;".
Page 2-1, subsection B.5. Delete "of Governemnt production".
Page 3-3, subsection E.2., line 3. Change "should" to "shall".
Page 3-4: subsection E.5., line 1. Change "should" to "shall".
subsection F.1., line 2. Change "lighting" to "lightning".
Page 4-6, paragraph B.3.h., line 2. Change "column 3" to "column 5".
Pages 6-10 through 6-12, Table 6-4, line 3 of title on each page. Change "paragraph G." to "paragraph D.".
Page 6-14, NOTE (d). Change "paragraphs" to "paragraph" and delete "and b.".
Page 6-16: Change "Figure 6-2." to "Figure 6-5.".
Change "Figure 6-3." to "Figure 6-2.".
Change "Figure 6-4." to "Figure 6-6.".
Change "Figure 6-5." to "Figure 6-3.".
Change "Figure 6-6." to "Figure 6-4.".
Page 6-22, Table 6-10: column 3, heading. Change "Public" to "Inhabited".
column 4, heading. Add "Public" above "Traffic".
Pages 6-33 and 6-34, Table 6-17, title, line 2. Add "for Airfields".
Page 6-35, Table 6-18. Change entries marked "3*" to "4" and delete the NOTE under the table.
Page 7-9, Table 7-3, above, columns 3 and 4. Change "group I" to "group II".
Page 7-16, Table 7-7. Add to end of table "Otto Fuel II" at "10.5" pounds/gallon at "77" ^{o}F temperature.
Page 8-1, section B., line 7. Add a semicolon after "electricity".
Page 8-5, section L., line 7. Delete the first "will also".
Page 11-6, paragraph L.2.c., line 2. Change "steams" to "streams".
Page 12-4, paragraph D.1.b., line 4. Change "class I" tc "division 1".
Page 12-7, subsection F.7., line 2. Change "should" to "shall".

NUMBER	DATE	DEPARTMENT OF DEFENSE
4145.26-M, Ch 1	June 12, 1987	PUBLICATIONS SYSTEMS TRANSMITTAL

INSTRUCTIONS FOR RECIPIENTS (continued)

PAGE CHANGES

Remove: Pages ii, iii, x through xvi, 1-1 through 1-4, 3-1, 3-2, 3-5 through 3-10, 6-1, 6-2, 6-7, 6-8, 6-17, 6-18, 6-23, 6-24, 8-7, 10-1, 10-2, 11-1, 11-2, 12-1, 12-2, 12-5, 12-6, 13-3, 13-4, 15-1 through 15-4, and 15-9.

Insert: Attached replacement pages

Changes appear on pages ii, x, xi, xiii, xiv, xv, xvii, 1-3, 3-1, 3-2, 3-5 through 3-8, 3-10, 6-1, 6-2, 6-7, 6-17, 6-23, 6-24, 8-7, 10-2, 11-1, 11-2, 12-1, 12-5, 13-3, 13-4, 15-2 through 15-4, and 15-9. The new page xvi contains the date of this transmittal.

EFFECTIVE DATE

The above changes are effective immediately.

James L. Elmer

JAMES L. ELMER, Director
Correspondence and Directives

Attachments
46 pages

SD FORM 106-2
1 MAR 84

DOD CONTRACTORS' SAFETY MANUAL FOR AMMUNITION AND EXPLOSIVES

Table of Contents

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21. Explosives Facility. Any structure or location containing ammunition and explosives.

* 21.1 Exposed Site (ES). A location exposed to the potential hazardous effects * (blast, fragments, debris, and heat flux) from an explosion at a potential * explosion site (PES). The distance to a PES and the level of protection * required for an ES determine the quantity of ammunition or explosives * permitted in a PES. *

22. Firebrand. A projected burning or hot fragment whose thermal energy is transferred to a receptor.

23. Fire-Resistive. Applies to generally combustible materials or structures that have been treated or have surface coverings designed to retard ignition or fire spread.

24. Firewall. A wall of fire-resistive construction designed to prevent the spread of fire from one side to the other. A firewall also may be termed a "fire divison wall."

25. Flame-Resistant. Applies to combustible materials, such as clothing, which have been treated or coated to decrease their burning characteristics.

26. Flammable. Combustible. A flammable material is one that is ignited easily and burns readily.

27. Fragmentation. Breaking up of the confining material of a chemical compound or mechanical mixture when an explosion takes place. Fragments may be complete items, subassemblies, pieces thereof, or pieces of equipment or buildings containing the items.

28. Hangfire. Temporary failure or delay in the action of a primer, igniter, or propelling charge.

29. Hazard Analysis. The logical, systematic examination of an item, process, condition, facility, or system to identify and analyze the probability, causes, and consequences of potential or real hazards.

30. High Explosive Equivalent or Explosive Equivalent. The ratio of the weight of TNT to that of another explosive when both quantities produce equivalent blast effects at the same distance from their detonations. The ratio is expressed as a precent.

31. Holding Yard. A location for groups of railcars, trucks, or trailers used to hold ammunition and explosives for interim periods before storage of shipment.

32. Hypergolic. The term used to describe the self-ignition of certain fuels and oxidizers upon contact with each other.

33. Inhabited Building. A building or structure, other than an operating building, occupied in whole or part by human beings; or a building or structure where people customarily assemble, such as a church, schoolhouse, railroad * station and similar transportation facilities, store, theater, or factory, inside or outside the establishment.

* 33.1 Inhabited Building Distance. That separation between explosives locations (PES) and nonassociated locations (ES) requiring a high degree of protection from an accidental explosion. Such exposed sites include: facility boundaries, wholly inert administrative facilities, the public, etc. *

34. Inspection Station. A designated location at which trucks and railcars containing ammunition and explosives are inspected.

35. Interchange Yard. An area set aside for the exchange of railroad cars or vehicles between the common carrier and establishment.

36. Intraline Distance. The distance to be maintained between any two operating buildings and sites within an operating line, at least one of which contains or is designed to contain explosives, except that the distance from a service magazine for the line to the nearest operating building will not be less than the intraline distance required for the quantity of explosives contained in the service magazine.

37. Launch Pads. The load-bearing base, apron, or platform upon which the rocket, missile, or space vehicle and its launcher are positioned.

38. Liquid Propellant(s). Liquid and gaseous substances (fuels, oxidizers, or monopropellants) used for propulsion or operation of missiles, rockets, and related devices (see table 7-1).

39. Loading Docks. Facilities structure, or paved areas, designed and installed for transferring ammunition and explosives. *

40. Magazine. Any building or structure, except an operating building, used for the storage of ammunition and explosives. The types and general specifications of various magazines for ammunition and explosives follow: * *

a. Army Igloo Magazines

(1) Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of the Army Office of Chief of Engineers drawings 652-686 through 652-693, dated December 27, 1941, as revised March 14, 1942; and drawings 33-15-58 (atomic blast resistant), 33-15-61, and 33-15-74, for all quantities of explosives up to 500,000 pounds.

(2) Reinforced concrete, arch-type, earth-covered magazines whose construction is at least equivalent in strength to the requirements of paragraph 40.a.(1), above, for quantities of explosives up to 250,000 pounds.

b. Navy Arch-Type Magazines

(1) Magazines constructed according to Navy drawings 357428 through 357430, dated August 9, 1944, and modified in accordance with Naval Facilities Engineering Command (NAVFAC) drawing 626739, dated March 19, 1954, or new magazines constructed according to NAVFAC drawings 627954 through 627957, 764597, 793747, 658384 through 658388, 724368, 751861, 764596, and 793746, for all quantities of explosives up to 500,000 pounds.

(2) Magazines constructed in accordance with NAVFAC drawings 649602 through 649605, 793748, and 803060, for all quantities of explosives up to 250,000 pounds.

c. Earth-Covered, Corrugated Steel, Arch-Type Magazine. Structures at least equivalent in strength to those shown on Army Office of Chief of Engineers (OCE) drawings numbered AW 33-15-63, dated March 5, 1963; AW 33-15-64, dated May 10, 1963; 33-15-65, dated January 10, 1963; NAVFAC drawings 1059128-30, 1059132, 1069906, or 1355460-61, for all quantities of explosives up to 500,000 pounds.

41. Mass Detonating Explosives. High explosives, black powder, certain propellants, certain pyrotechnics, and other similar explosives, alone or in combination, or loaded into various types of ammunition or containers, most of which can be expected to explode virtually instantaneously when a small portion is subjected to fire, to severe concussion or impact, to the impulse of an initiating agent, or to the effect of a considerable discharge of energy from without. Such an explosive will normally cause severe structural damange to adjacent objects. Explosive propagation may occur immediately to other items of ammunition and explosives stored sufficiently close to and not adequately protected from the initially exploding pile with a time interval short enough so that two or more quantities must be considered as one for quantity/distance (Q/D) purposes.

42. Maximum Credible Event (MCE). In hazards evaluation, the MCE from a hypothesized accidental explosion, fire, or agent release is the worst single event that is likely to occur from a given quantity and disposition of ammunition and explosives. Event must be realistic with a reasonable probability of occurrence, considering the explosion propagation, burning rate characteristics, and physical protection given to the items involved. The MCE evaluated on this basis may then be used as a basis for effects calculations and casualty predictions.

43. Military Pyrotechnics. Ammunition manufactured specifically for use as signals, illuminants, and like items.

44. Misfire. Failure of a component to fire or explode as intended.

45. Navigable Streams. Those parts of streams, channels, or canals capable of being used as highways of commerce over which trade and travel are or may be conducted, excluding streams that are not navigable by barges, tugboats, and other large vessels, unless they are used extensively and regularly for the operation of pleasure boats.

46. NEW. Net Explosive Weight, expressed in pounds.

47. Nitrogen Padding (or Blanket). Filling the void or ullage of a closed container with nitrogen gas to prevent oxidation of the chemical therein and to avoid formation of a flammable atmosphere above the liquid. Nitrogen padding (or blanket) also means maintaining a nitrogen atmosphere in or around an operation, piece of equipment, etc.

48. Noncombustible. Not burnable.

49. Operating Building. Any structure, except a magazine, in which operations pertaining to manufacturing, processing, handling, loading, or assembly of ammunition and explosives are performed.

50. Operating Line. A group of buildings, facilities, or related work stations so arranged as to permit performance of the consecutive steps in the manufacture of an explosive or in the loading, assembly, modification, and maintenance of ammunition.

51. Operational Shield. A barrier constructed at a particular location or around a particular machine or operating station to protect personnel, material, or equipment from the effects of a possible localized fire or explosion. Operational shields, when properly designed in accordance with MIL-STD 398 (reference (a)) should protect personnel and assets from thermal, pressure, and fragmentation hazards resulting from an accidental or intentional detonation and deflagration of ammunition or explosives. Existing reinforced concrete walls built to resist the effects of accidental explosions and designed and built in accordance with requirements applicable at the time of construction may be used as operational shields, with the following guidance as a minimum requirement:

* a. A 12-inch reinforced concrete wall (see definition 64.) provides adequate protection for operations involving an item containing 15 pounds TNT equivalent or less of high explosives when the nearest part of the item is at least 3 feet from the wall and the item is 2 feet from the floor. Care shall be taken to use appropriate equivalence data for close-in effects. Explosives characterized by greater brisance than that of TNT may have very high equivalencies at small distances from the explosives. When equivalence data is not available, existing 12-inch reinforced concrete walls may be used for operational shields for protection from items containing not more than 6 pounds of high explosives.

b. A 30-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 50 pounds TNT equivalent of high explosives. The same separation distance as stated in paragraph 51.a., above, applies. When equivalence data is not available, a 30-inch wall may be used for an operational shield for protection from items containing not more than 20 pounds of high explosives.

c. A 36-inch reinforced concrete wall provides adequate protection against the effects of an item containing not more than 70 pounds TNT-equivalency of high explosives. The separation distance as stated in paragraph 51.a., above, applies. When equivalence data is not available, a 36-inch wall may be used for an operational shield for protection from items containing not more than 20 pounds of high explosives.

* 51.1 Potential Explosive Site (PES). The location of a quantity of explosives that will create a blast, fragment, thermal, or debris hazard in the event of an accidental explosion of its contents. Quantity limits for ammunition and explosives at a PES are determined by the distance to an ES.

52. Prohibited Area. A specifically designated area at airfields, seadromes, or heliports in which all ammunition and explosives facilities are prohibited.

* 53. Propellant. Explosives compositions used for propelling projectiles and rockets and to generate gases for powering auxiliary devices. *

54. Public Highway. Any street, road, or highway used by the general public for any type of vehicular travel.

55. Public Traffic Route. Any public street, road (including any on an establishment or military reservation), highway, navigable stream, or passenger railroad that is routinely used for through traffic by the general public.

56. Pyrotechnic Material. The explosive or chemical ingredients, including powdered metals, used in the manufacture of military pyrotechnics.

57. Quantity/Distance (Q/D). The quantity of explosives material and distance separation relationships providing defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q/D tables. Separation * distances afford less than absolute safety. *

58. Renovation. That work performed on ammunition, missiles, or rockets to restore them to a completely serviceable condition; usually involves the replacement of unserviceable or outmoded parts.

59. Restricted Area. Any area, normally fenced, from which personnel, aircraft, or vehicles, other than those required for operations, are excluded for reasons of safety.

60. Runway. Any surface on land designated for aircraft takeoff and landing operations, or a lane of water designated for takeoff and landing operations of seaplanes.

* 61. Service Magazine. A building in an operating line used for the intermediate storage of explosives materials. The amount of explosives normally is limited to a minimum consistant with safe, efficient production. *

* 62. Standard Igloo Magazine. An earth-covered, arch-type magazine, with or without a separate door barricade, constructed according to an approved standard drawing. *

* 63. Static Test Stand. Locations whereon liquid propellant engines or solid propellant motors are tested in place. *

* 64. Substantial Dividing Wall. An interior wall designed to prevent simultaneous detonation of explosives on opposite sides of the wall. However, such walls may not prevent propagation (depending on quantities and types of explosives involved). *

a. Substantial dividing walls are one way of separating explosives into smaller groups to minimize the results of an explosion and allow a reduction in Q/D. These walls do not protect personnel near the wall from high explosives because the spalling of wall surface opposite the explosion source may form dangerous secondary fragments.

b. Reinforced concrete-type walls may vary in thickness, but will be at least 12 inches thick. At a minimum, both faces will be reinforced with rods at least 1/2 inch in diameter. The rods will be spaced not more than 12 inches on centers horizontally and vertically, interlocked with the footing rods and secured to prevent overturning. Rods on one face will be staggered with regard to rods on the opposite face and should be approximately 2 inches from each face. Concrete should have a design compressive strength of 2,500 psi or more. The capability to prevent simultaneous detonation is based on a limit of 425 net pounds of mass-detonating explosives. All storage plans and Q/D calculations shall be based on the total quantity of mass-detonating explosives on both sides of a dividing wall when the quantity of either side exceeds 425 pounds. Explosives should be 3 feet or more from the wall.

c. Retaining walls filled with earth or sand must be at least 5 feet wide, with earth or sand packed between concrete, masonry, or wooden retaining walls.

* 65. Suspect Truck and Car Site. A designated location for placing trucks and railcars containing ammunition or explosives that are suspected of being in hazardous condition. These sites also are used for trucks and railcars that may be in a condition that is hazardous to their contents. *

* 66. Taxiway/Taxilane. Any surface designated as such in the basic airfield clearance criteria specified by a DoD Component publication or Federal Aviation Administration Regulation (reference (b)). *

* 67. Waiver. Written authority that provides a temporary exception, permitting deviation from mandatory requirments of this Manual. It generally is granted for short periods of time pending cancellation as a result of termination of scheduled work commitments or correction of the waived conditions. *

#First Amendment (Ch 1, 6/12/87)

GLOSSARY OF ACRONYMS

ACO	-	Administrative Contracting Officer
A&E	-	Ammunition and Explosives
CBU	-	Cluster Bomb Unit
COCO	-	Contractor-Owned, Contractor-Operated
DNT	-	Dinitrotoluane
DoD	-	Department of Defense
DOT	-	Department of Transportation
DTA	-	Differential Thermal Analysis
ES	-	Exposed Site
FAA	-	Federal Aviation Administration
FAE	-	Fuel Air Explosive
HC	-	Hexachloroethane
HE	-	High Explosive
IHE	-	Insensitive High Explosive
IMO	-	International Maritime Organization
IR	-	Infrared
LP	-	Liquified Petroleum
MCE	-	Maximum Credible Event
MILVANS	-	Military Vans/Tractor Vans (i.e., 8'x8'x20' container)
MK	-	Mark
MOD	-	Model
NATO	-	North Atlantic Treaty Organization
NAVFAC	-	Naval Facilities Engineering Command
NEC	-	National Electrical Code
NEW	-	Net Explosive Weight
NFPA	-	National Fire Protection Association
OCE	-	Office of Chief of Engineers
PCO	-	Procuring Contracting Officer
PES	-	Potential Explosive Site
PETN	-	Pentaerythritol Tetranitrate
POPO	-	Privately Owned-Privately Operated
PSI	-	Pounds Per Square Inch
PSIG	-	Pounds Per Square Inch Guaze
PWP	-	Plasticized White Phosphorous
Q/D	-	Quantity/Distance
RDX	-	Cyclonite
RF	-	Radio Frequency
SCG	-	Storage Compatibility Group
SOP	-	Standard Operating Procedure
TEA	-	Triethylaluminum
TNT	-	Trinitrotoluene
TP	-	Target Practice
TPA	-	Thickened TEA
UL	-	Thickened TEA
UV	-	Ultraviolet
UNO	-	United Nations Organization
WP	-	White Phosphorus

REFERENCES

(a) MIL-STD 398, "Shields, Operational for Ammunition Operations, Criteria for Design of and Tests for Acceptance" (current edition)
(b) Federal Aviation Administration Regulation, "Objects Affecting Navigable Airspace" (14 CFR 77)
(c) DoD Directive 6055.9, "The DoD Explosives Safety Board," November 25, 1983
(d) TM 5-1300, AFM 88-22, and NAVFAC P-397, "Structures to Resist the Effects of Accidental Explosions," June 1969
(e) TB 700-2, NAVSEA Instruction 8020.8, TO11A-1-47, DLAR 8220.1, September 1982
(f) Joint Services Safety and Performance Manual, 1972
(g) WR-50, Naval Weapons Requirements, Warhead Safety Tests, Minimum for Air, Surface and Underwater Launched Weapons (excluding mine and nuclear warheads), CODE IDENT 10001, Department of the Navy, Bureau of Naval Weapons, February 13, 1964.
(h) NAVAIR 00-130-ASR-2-1, Joint Munitions Effectiveness Manual, "Air-to-Surface Joint Service Test Procedures for Bombs and Bomblets," December 1968
(i) National Fire Protection Association (NFPA), National Fire Codes/Standards
* 13, 15, 33, 48, 70, 77, 78, and 491M (current Codes/Standards) *
(j) National Electric Code (NEC) (current edition)
(k) Federal Aviation Administration Handbook (current edition)
* (l) ANSI Z16.4, "Uniform Record Keeping for Occupational Injuries and *
* Illnesses" *

*#First Amendment (Ch 1, 6/12/87)

CHAPTER 1

INTRODUCTION

A. PURPOSE

This Manual provides reasonable and standardized A&E safety principles, methods, practices, requirements, and information for contractual work or services performed in connection with contracts involving A&E. Understanding and compliance with the applicable requirements of this Manual and additional safety requirements of the contract, if any, should minimize the potential for mishaps that could interrupt DoD operations or delay production delivery dates, adversely impact upon DoD production capabilities, damage or destroy DoD material/equipment, cause injury to DoD personnel, or endanger the general public. Therefore, adherence to the Manual's standards and principles will support DoD mission accomplishment, provide a safe environment for contract work and enhance cooperation and assistance from DoD personnel.

B. APPLICABILITY

This Manual applies to contractors performing work or services on DoD contracts, subcontracts, purchase orders, or other purchasing methods for ammunition or explosives as defined within the contract. These safety standards are minimum requirements and shall be accepted as final authority over applicable A&E contractor operations and their locations, whether inside or outside of the establishment.

C. MANDATORY AND ADVISORY STANDARDS

The standards contained in this Manual that use the terms "shall," "must," and "will" are considered mandatory requirements. Waivers to these requirements may be authorized by the procuring contracting officer (PCO) as explained in paragraph E.1. and 2., below. The terms "should" and "may" are advisory when used in this Manual. When advisory provisions are not met, adverse consequences may develop, becoming proximate causes of A&E mishaps.

D. RESPONSIBILITIES

The contractor or subcontractor is responsible for adhering to the following:

1. Complying with the requirements of this Manual and any other safety requirements contained within the contract.

2. Developing and implementing a demonstrable safety program (in addition to operational procedures) that ensures mishap prevention in contractural activities.

3. Designating qualified individuals to administer and implement this safety program.

4. Providing information to the Administrative Contracting Officer (ACO) pertaining to subcontractors retained for A&E work. Providing advice and assistance to subcontractors during their work performance.

5. Conducting mishap investigations in accordance with, but not limited to, provisions of this Manual.

E. COMPLIANCE WITH MANDATORY STANDARDS

1. During preaward safety surveys, violations of mandatory standards contained in this Manual must be resolved. The contractor may choose to correct the deficiencies immediately, submit a written letter of intent to correct the deficiencies (which will become binding if awarded the contract), or request acceptance of specifically identified existing conditions/facilities by the purchasing activity.

2. When the contractor cannot comply with the mandatory safety provisions of the contract, the contractor will develop and submit a request for a waiver through the ACO to the Procuring Contracting Officer (PCO) for final determination. The request will contain complete information concerning the standards violated, actions planned to minimize the hazard, and a proposed date of completed corrective action to eliminate the stated noncompliance.

F. SITE AND CONSTRUCTION PLANS

1. Development and submission of site plans, modifications, construction, and utilities drawings pertaining of DoD-owned facilities will be processed in accordance with the requirements of DoD Directive 6055.9 (reference (c)), as implemented by the applicable Military Service requirements.

2. For contractor-owned, contractor-operated (COCO) facilities, the contractor shall submit, to the ACO, site and construction plans for all new construction or major modification of facilities for ammunition and explosive activities and for the facilities that may be exposed to A&E hazards if improperly located. The contractor will not begin construction/modification of proposed facilities until receiving site and construction plan acceptance from the ACO.

3. Modification or rehabilitation plans for existing facilities that are essentially minor, introduce no new hazards, and do not increase the net explosive capacity for which the facility was designed or sited, need not be submitted. (The ACO will make the final determination as to whether a site plan is necessary.)

4. Site plans shall contain the following:

a. Drawings scaled at not less than 1 inch to equal 400 feet. Smaller-scale drawings may sometimes be necessary to reflect certain distance and structure relationships within the area surrounding a given project. In such instances, reductions in scale are acceptable.

b. Indication of distances between the facility and other installation facilities, the installation boundary, public railways, and public highways, including power transmission and utility lines.

c. Identification of all other facilities within inhabited building distance of the facility, with a brief description of the nature of occupancy of the former.

d. Descriptions of A&E items or hazardous materials to be in the facilities, that is, bombs, rockets, artillery ammunition, liquid propellants, or other items requiring protective measures in accordance with this Manual.

e. Indication of net explosives weight, number of units and class(es) of ammunition, explosives, liquid and solid propellants, or other hazardous materials proposed for the facility, including a breakdown by room or bay.

f. Indication of net explosives weight, number of units and class(es) of ammunition, explosives, liquid and solid propellants, or other hazardous materials in facilities located within inhabited distance of the facility.

* g. Identification of all facilities whose inhabited building distance arcs include the facility under consideration. *

* 5. Construction plans shall contain the information in paragraphs F.4.a. through f., above, and the following: *

a. Anticipated personnel limits for the new or modified facility, including a breakdown by room or bay, when appropriate.

b. General details regarding dividing walls, vent walls, firewalls, roofs, operational shields, barricades, exits, types of floor finish, fire protection system installations, electrical systems and equipment, ventilation systems and equipment, A&E waste disposal systems, lightning protection systems, static grounding systems, process equipment, and auxiliary support structures, as well as general materials of construction.

c. Information relative to the types and arrangment of explosive operations or chemical processing equipment.

d. A topographical map with appropriate contours when terrain features are considered to constitute natural barricading, or when topography otherwise influences layout.

e. Explanation of any deviations from pertinent safety standards due to local conditions.

G. PREAWARD SAFETY SURVEY

* 1. When A&E materials and operations are involved in a solicitation, mishaps could adversely effect production capability, production assets, or long lead time products/services essential to DoD program milestones; therefore the contractor's capability and preparedness must be evaluated. Preaward safety surveys will be conducted by DoD safety personnel. *

2. During the preaward safety survey, the contractor, at a minimum, must be prepared to assist by providing the following for review:

a. Site plans conforming to the requirements of paragraphs F.4.a. through f., above.

b. Safety program, organization, and training.

c. Fire prevention program and available firefighting resources, including local agreements.

d. Description of facilities including size, construction design and materials, fire resistive capability, utilities, and current compliance with existing building regulations and codes.

e. Operational compliance with applicable Federal, state, and local requirements. All operations that may adversely affect the proposed schedule of work or related structures if a mishap occurs, including similar A&E operations, will be reviewed.

f. Required licenses or capability to obtain those required to perform proposed contract work.

g. Past safety history, including reports of safety surveys by Federal, state, or local safety, fire prevention, insurance, or other authorities; current status of waivers or exemptions issued by Federal, state, or local authorities; mishap experience.

h. A&E collection and disposal systems and procedures. The contractor may wish to request specific clarification of A&E residue/reject item disposition at this time.

i. Hazard analysis, as appropriate.

H. PREOPERATIONAL SURVEY

After contract award, Government review and evaluation of the facilities/operations may be necessary before startup of production/services. The contractor will therefore contact the ACO to offer an opportunity for a preoperational review by authorized DoD personnel.

CHAPTER 3

SAFE PRACTICE STANDARDS

A. GENERAL

This chapter provides general safe practice standards applicable to all A&E operations addressed in this Manual. When these standards exceed or differ from local or national codes or standards, the more restrictive shall apply.

B. PERSONNEL AND MATERIALS LIMITS

1. The cardinal rule to be observed in any location or operation involving explosives, ammunition, severe fire hazards, or toxic materials is tc limit exposure to a minimum number of personnel, for a minimum amount of time, to the minimum amount of the hazardous material consistent with safe and efficient operations. All operations shall be examined to devise methods for reducing the number of people exposed, the time of exposure, and the quantity of material subject to a single incident. Determination of personnel limits requires that jobs not essential to a particular hazardous operation be performed elsewhere; that no unnecessary personnel visit the location; and that frequent, consecutive operations will not be permitted in the same room or building without adequate dividing walls, firewalls, or operational shields, depending upon the nature * of the hazard. Personnel limits should allow for necessary supervision, workers, * and transient workers.

2. Determination of limits for hazardous materials requires a careful analysis of all facts including operation timing, intraplant transportation methods, size of the items, and the chemical and physical characteristics of the material. Stricter limits are required for the more sensitive or hazardous materials. Limits should be established for each operation rather than on an overall basis, so that each worker may be charged with the responsibility of not exceeding the established limit. Limits need not be expressed in units of weight or in the number of items as such. They may be given in terms of trays, boxes, racks, or other units more easily observed and controlled. Explosives limits shall not be established on the basis of the maximum quantity of explosives allowable as defined by the existing quantity/distance separation to nearby exposures when lesser quantities of explosives will suffice for the operations.

3. The maximum personnel and explosives limits permitted at any one time shall be prominently displayed in all buildings, cubicles, cells, and rooms containing A&E. These limits must be kept current, and enforced by the supervisor, foreman, or worker in charge. The personnel and explosives limits for all operations shall be recorded in the applicable Standard Operating Procedure (SOP). Personnel limits need not be posted in storage magazines, magazine areas, or transfer points. Explosives limits need only be posted in storage magazines for which the limit differs from that for other magazines in the block, or when unusual circumstances prevent the limit from being readily apparent.

C. STANDING OPERATING PROCEDURES (SOPs)

The basic requirement is for all operations involving hazardous materials to be developed in advance, and expressed in such a way as to avoid confusion and ensure process control at all times. An adequate SOP shall be developed, * reviewed, and approved by qualified personnel before starting any operation * involving A&E.

1. Preparation. All aspects of a procedure shall be examined to determine a safe and orderly course of action for accomplishing the work. Controlled tests may be necessary in order to establish SOPs for certain operations. The SOP shall include, at a minimum, such items as safety requirements; specific emergency procedures; personal protective clothing and equipment; personnel and explosives limits for each operation; equipment designation; location and sequence of operations; and the particulars regarding how, when, where, and by whom each task of the operation shall be performed.

2. Dissemination. Supervisors shall be responsible for explaining duties prescribed by the SOP to all personnel involved in an A&E operation.

3. Posting. Applicable portions of the approved SOP, determined by the managing authority to be necessary to facilitate operations, shall be posted in a spot convenient to all stations involved in the operation. This need not be at the work station if the worker could be distracted, causing an accident. Supervisory personnel should maintain copies of the entire SOP; they must assume responsibility for enforcing its provisions.

4. Emergency Procedures. Action to be taken in the event of electrical storms, utilities, or mechanical failures and the like, occurring during the manufacturing, handling, or processing of A&E and other hazardous materials, shall be set forth in the SOP as described in the preceding paragraphs, or shall be set forth in separate SOPs prepared specifically for such purposes.

5. Recertification. SOPs should be constantly reviewed by qualified personnel, and changed and recertified by the managing authority as often as necessary to reflect improved methods, equipment substitutions, facility modification, or process revisions.

6. Training. Operator training should cover approved safety procedures, hazardous materials information, safety and warning devices, personal protective clothing and equipment, and emergency equipment.

D. STORAGE IN OPERATING BUILDINGS

1. Only those quantities of hazardous materials (excluding explosives and pyrotechnic materials) essential for current operations shall be stored within an operating building. Explosive materials exceeding work requirements shall be stored in a separate service storage magazine area located at the appropriate intraline distance from the operating building or area, based on the quantity of explosives stored in the service magazine.

2. If the intraline distance required by operational necessity is not available, contractors may designate in-process holding containers/structures within the operating building, provided the following apply:

d. Locations, with or without lightning protection, where operations involving electro-explosive devices are being performed.

2. A qualified person, in authority should make the final decision about evacuation. When special warning is required for shutdown, volunteer observers or a detector (lightning detection system) may be used.

* 3. Personnel shall be evacuated from an operating line and proceed to * locations identified in the SOP. These locations shall be at intraline distance * or greater. *

G. EXPLOSIVES IN PROCESS DURING SHUTDOWN

When electrical storms cause evacuation of buildings with explosives, operations requiring constant attention shall continue to be manned by the minimum number of personnel consistent with safety requirements. Once the process has reached a condition in which it is considered safe to leave, the building shall be completely evacuated. No explosives process requiring constant attention * should be started when an electrical storm threatens. *

H. MAINTENANCE AND REPAIRS TO EQUIPMENT AND BUILDINGS

1. All new or newly repaired processing equipment must be examined and tested to ensure that it is in safe working condition before being placed into routine use in hazardous operations.

2. Before repairs can proceed on equipment exposed to explosives, a tag certifying that no explosives remain, signed by supervisory personnel, shall be placed on the equipment. The tag shall identify parts that could not be cleaned, and shall provide maintenance personnel with instructions on safe handling.

3. Major repairs or changes will not be undertaken in a building during regular operations until the hazardous material has been removed and the employee in charge of the building informed.

4. Repairs cannot start in an explosives location until all explosives and dust found during an inspection of the immediate vicinity have been removed from equipment, crevices, areas beneath floors, within walls and pipes, and under fittings where explosives could be ignited. The entire area should be wetted or washed down thoroughly.

5. After oiling, fixing, or adjusting machines and equipment, the tools used for the repairs shall be removed. Before work resumes, operators should check their own equipment to ensure its safe operating condition.

* 6. Electricians shall not wear conductive shoes while working on electrical * equipment. Exposed explosives and other static-sensitive hazardous material must be removed before electrical work begins.

7. Safe practices specified elsewhere in this Manual shall also apply to maintenance employees.

8. Maintenance and tool rooms in an operating line should be separated from explosives by intraline distance. Protection equivalent to that afforded by a suitable barrier shall be provided when this proves impractical.

I. SAFETY HANDTOOLS

1. Handtools constructed of wood or materials such as bronze, lead, beryllium alloys, and "K" Monel metal shall be used for work in locations that contain exposed explosives or hazardous concentrations of flammable dusts, gases, or vapors. The nonferrous metals used in so-called nonsparking tools can produce sparks.

2. If their strength makes the use of ferrous metal handtools necessary, exposed explosives and other highly combustible materials shall be removed from the area as required in paragraphs H.2., 3., and 4., above.

J. OPERATIONAL SHIELDS

The design and testing of operational shields shall be in accord with * MIL-STD 398 (reference (a)). Tests shall be tailored to address the credible * * hazards of the operation. Interlocking devices shall be installed on any equipment used for explosives processing (the doors of which function as operational shields). This prevents the operator from inadvertently opening such doors while working.

K. SPECIAL CLOTHING

1. A changing area should be established for employees who must remove their street clothes to wear special clothing (explosives plant clothing, anticontamination clothing, impervious clothing, etc.). To avoid exposing people not involved in A&E operations to unnecessary risks, special clothing worn during A&E operations shall not be worn or taken away from the premises. Special clothing should not be altered. Cotton undergarments, including socks, shall be worn whenever generating static electricity could create a hazard.

2. Explosives plant clothing, generally referred to as powder uniforms, must be fastened with nonmetallic fasteners and easily removable. Pockets should be of the lattice type. Pants and sleeves should be tapered and without cuffs, and pants should extend over the tops of shoes or boots. These garments should be flame resistant or made of flame retardant material. Each plant should have laundering facilities available for removing contaminants from explosives plant clothing. Regular testing will verify the effectiveness of the laundering operations.

L. CONDUCTIVE FOOTWEAR

* 1. When conductive mats, floors, and runners are required, operators shall * * wear conductive shoes. Personnel visiting any such area shall wear conductive * shoes, ankle straps, or similar devices.

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2. Tests of conductive shoes, or equivalent, shall be made initially and daily thereafter to ensure that the resistance from person to ground (through conductive flooring) is less than one million ohms. Documentation of this testing, to include calibration of test equipment, shall be kept by supervisory personnel. The test voltage must not exceed 500 volts. The short circuit current across the electrodes (plates) must not exceed 2.0 milliamperes (0.5 milliamperes is preferred). The instruments shall have built-in safeguards preventing the test subject from experiencing electric shock. Tests must not be performed in rooms with exposed explosives. Shoes should be tested first without cleaning the soles and heels; if the the resistance does not exceed allowed levels, the shoes may be worn. If resistance exceeds 450,000 ohms per shoe, the pair must be cleaned and re-tested. Sandpaper, solvents, or other * agents affecting the structure or conductivity of the sole materials should * not be used. Separating or removing the conductive sock liner from the conductive plug or depressing the conductive plugs below the surface of the insole of the shoe can cause high resistance. Nonconductive stockings such as silk, wool, and synthetics; and foot powders, which have a drying action, shall be avoided. Conductive shoes should be clearly labeled as such.

M. MATERIALS HANDLING EQUIPMENT

1. Gasoline-, diesel-, and LP-powered equipment will not be refueled inside warehouses or similar essential buildings containing ammunition and explosives. If the fuel supply is exhausted while the equipment is inside a building, the equipment shall be towed outside to a safe location for refueling: at least 20 feet from warehouses, other inert buildings, and inert loading docks; and 90 feet from explosives locations or buildings. Doors and windows through which vapors may enter the building shall be closed during refueling. Refueling trucks will not be located close to explosives buildings during refueling operations, but shall be parked as far as practicable from these buildings, in accordance with the above standards.

2. Gasoline-, diesel-, and LP-powered equipment will not be stored in buildings containing explosives or ammunition or on explosives loading docks or piers when A&E is present.

3. A central storage location for gasoline-, diesel-, and LP-powered equipment is preferred. Such a building should be located at least 50 feet from other buildings to avoid a fire hazard.

N. PARKING OF PRIVATELY OWNED VEHICLES

Controlled parking of privately owned vehicles within an establishment minimizes fire and explosion hazards and prevents congestion in an emergency. Vehicles should be parked in designated areas only, at intraline distance and outside of restricted areas. Vehicles shall not be parked so close to an explosives building or structure that fire could spread from them to the building, or that they could impede firefighters.

O. PROHIBITED ARTICLES IN HAZARDOUS AREAS

Except as authorized, personnel must not carry matches, cigarette lighters, or other flame-producing devices into explosive areas. Personal articles that increase existing hazards are also prohibited.

P. PHOTOGRAPHIC MATERIALS IN HAZARDOUS AREAS

Photoflash bulbs or electronic flash attachments shall not be used around exposed explosives, explosive dusts, flammable gases, or vapors. Only lighting * equipment approved by a nationally recognized testing laboratory shall be used. *

Q. OPERATIONAL EXPLOSIVES CONTAINERS

1. Explosives must be placed in containers that will prevent leakage. Containers used for intraplant transportation operations or service storage of explosives, such as initiating explosives, pyrotechnic compositions, and tracer materials, should be made of material in the following order of preference:

a. Conductive rubber.

b. Nonferrous metal-lined boxes without seams or rivet heads under which explosive dusts could accumulate.

c. Plastics (conductive type only).

d. Paper-lined wooden boxes.

e. Fiber drums.

* 2. These containers should be the same size, shape, and color; marked with * the type of explosives or hazard involved.

3. Because of their fragility and potential to fragment, glass containers * shall not be used. *

R. INTRAPLANT RAIL TRANSPORTATION

This section addresses intraplant transportation safety standards and may exceed national standards because of material characteristics and operational hazards. When construction or major modification of transportation, packaging, or loading facilities is planned or anticipated, the contractor is responsible for ensuring that applicable Federal, State, and local standards and those contained within this Manual are met. The applicable standards promulgated by Department of Transportation (DOT) and other Federal or local regulatory agencies concerning preparation, marking, and shipment of ammunition and explosives should appear in the contract.

1. Operating Rules. Local procedures to ensure safe and efficient rail movement of A&E shall be developed, and shall include the following minimum requirements, as applicable:

a. Movements in the classification yards are considered switch movements. All others are considered transfer movements. Before cars containing A&E move, air hoses shall be coupled, air brakes cut-in and in proper working order, and the car doors closed. Cars should remain coupled while in motion. Safety precautions shall be observed when breaking air hose connections.

b. When single explosives-loaded cars are spotted, the hand brakes shall be set and the wheels properly chocked. When more than one car is spotted and its engine detached, the handbrakes shall be set on enough cars to ensure sufficient braking. Handbrakes shall be set on the downgrade end of the cut of cars. Reliance should not be placed on the automatic air brakes to hold spotted cars.

c. A person should be stationed at the handbrake of a car mover being used to move a car.

d. During transfer movements within establishments, full or partial loads in cars being moved by locomotives shall be blocked and braced so they cannot shift position.

e. Empty cars shall remain in warehouses, magazines, buildings, or loading docks until all warning placards have been removed or reversed, as appropriate.

f. Special care shall be taken to avoid rough handling of cars containing A&E. These cars will not be "sent off" while in motion and shall be carefully coupled to avoid unnecessary shocks. Other cars will not be "cut off" and allowed to strike a car containing explosives.

g. A bumper car should separate railcars containing explosives and the switching engine when in motion.

h. Flags or signals at both ends of a car or cut of cars shall protect personnel working in, on, or under the cars. During these periods, cars must not be coupled or moved.

i. Portable transmitters and railroad locomotives equipped with two-way radios will not transmit when passing explosives operating buildings where electro-explosive devices are in use. The contractor shall determine minimum safe distances based on Radio Frequency (RF), Frequency Modulation (FM), and Amplitude Modulation (AM) energies involved.

2. Railcar Inspections

a. Qualified personnel shall inspect empty railcars intended to transport A&E upon arrival, verifying that the carrier has complied with DOT requirements.

b. Before loading, the brakes shall be set on cars spotted for loading, and bridge plates equipped with side boards and stops shall be provided.

3. Loaded Incoming Railcar Inspection

a. Railroad cars with A&E should, upon arrival, be inspected at remote sites complying with Q/D requirements.

b. A&E-loaded cars on which foreign and suspicious articles have been attached outside or underneath the car, or that have a defect which could affect the safety of the installation or the contents of the car, shall be removed to the suspect car site for additional inspection.

c. After passing the exterior inspection, cars may be opened for interior inspection at the remote site (paragraph 3.a., above) or at the designated unloading point.

d. Cars should be inspected after unloading A&E to ensure that they are clean and free from loose explosives and flammable materials, and that placards and car certificates have been removed. Explosives sweepings shall * be disposed of properly. *

S. INTRAPLANT MOTOR VEHICLE TRANSPORTATION

1. Vehicle Inspection. All motor vehicles used to transport A&E shall be * inspected daily to ensure the following: *

a. Batteries and wiring shall not come into contact with containers of A&E.

b. When portable lights or flares are required (mandatory in some states on public highways), they shall be of the approved magazine type or of the type designated "permissible" by the United States Bureau of Mines.

c. Exposed ferrous metal in the interior of the vehicle body shall be covered with nonsparking material when scrap and bulk explosives are being transported in containers that could be damaged, or when explosives could otherwise become exposed.

d. A portable fire extinguisher of the appropriate class shall equip any vehicle transporting A&E.

e. Motor vehicles transporting A&E within the establishment but outside the explosives area, shall bear at least two appropriate placards. These placards should be removed or covered whenever the vehicle is not loaded. Reflectorized placards are preferred.

f. Motor vehicles or equipment with internal combustion engines, used near explosives scrap, waste, or items contaminated with explosives, shall have exhaust system spark arrestors and carburetor flame arrestors (authorized air cleaners). They should be inspected and be cleaned when excessive carbon particles have accumulated.

2. Operating Rules. Procedures for safely and efficiently moving A&E in motor vehicles shall be developed locally, and should include the following:

a. Brakes shall be set and the wheels chocked while loading and unloading on a grade.

b. A&E should not be loaded or unloaded when a motor vehicle's engine is running, unless the engine is providing power to accessories used in the loading and unloading, such as mechanical handling equipment.

CHAPTER 6

HAZARD CLASSIFICATION AND Q/D CRITERIA

A. GENERAL

1. This chapter outlines Q/D requirements applicable to storage, processing, and handling of A&E. The maximum amount of explosives permitted at any location is determined by the prevailing distance from that location to other exposures and the applicable Q/D table in this chapter. Greater distances than those shown in the tables should be used when practicable.

2. When sufficient protection can be provided by hardening a target building or constructing a source building to suppress explosion effects, this may be taken into account, and the distance required by the standard Q/D tables may be reduced. The rationale or test results justifying the proposed distance reduction must accompany A&E site and general construction plans when submitted through the ACO for the PCO's approval. (See Chapter 1, paragraph F.)

B. HAZARD CLASSES AND CLASS DIVISIONS

1. The hazard classification system is based upon the system recommended for international use by the United Nations Organization (UNO), consisting of nine classes for dangerous goods with ammunition and explosives included in UNO's "Class 1, explosives."

2. The A&E hazard classes are further subdivided into "divisions" according to the associated hazards, including the potential for causing personnel casualties or property damage. The list of items for each division contains examples; it is not all-inclusive.

3. The separation of the A&E hazard classes into the several divisions does not necessarily mean that the different items in a division may be stored together. Also, some items may appear in more than one division, depending upon factors such as the degree of confinement or separation, type of packaging, storage configuration, or state of assembly.

4. The maximum amount of explosives permitted in any location is limited by the Q/D criteria. Explosives limits shall be established in amounts no greater than those consistent with safe and efficient operations.

* 5. Class 1 is divided into the following divisions that indicate the type of hazards expected: *

Hazard Class and Division Designators	Hazards
1.1	Mass detonating
1.2	Nonmass detonating Fragment producing
1.3	Mass fire
1.4	Moderate fire, no blast
1.5	Insensitive high explosives

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6. A numerical figure (in parenthesis) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands. This number will be placed to the left of the division designators 1.1 through 1.3, such as (18)1.1, (08)1.2, and (06)1.3. A minimum distance as shown in applicable tables will be used for all items in division 1.2.

a. For divisions 1.1 and 1.3, a minimum distance number will be used where the ranges of hazardous fragments and firebrands EXCEED the distances specified for inhabited buildings in the applicable Q/D table.

b. Minimum fragment distance protects personnel in the open; firebrand minimum distance primarily protects facilities.

c. Examples where minimum fragment and firebrand distances for divisions 1.1 and 1.3 need not be applied follow:

(1) Recreation or training facilities, if these facilities are for the exclusive use of personnel assigned to the potential explosion site.

(2) Between potential explosion sites and relatively static inert storage areas.

(3) Between facilities in an operating line, between operating lines, and between operating lines and storage locations normally separated by inhabited building distances to protect workers and ensure against interruption of production.

d. For demolition explosives, thin-cased or low-fragmentation ammunition items, bulk high explosives, pyrotechnics, and in-process explosives of division 1.1, the minimum distance to exposures will be 670 feet for 100 pounds NEW or less. For all division 1.1 A&E in quantities of 101 to 30,000 pounds * NEW, the minimum distance will be 1,250 feet. The above distances may be * * reduced when it is shown by test data that reductions are warranted. For items * that have been evaluated adequately, different minimum distances, as in table 6-2, may be used. In the application of this paragraph, "thin-cased" will refer to items presenting no more hazard from high-velocity primary fragments than a single 500-pound MK 82 bomb. (Facilities sited at 1,235 or 1,245 feet in accordance with past standards will be considered to be in compliance with the 1,250 foot minimum requirement.)

e. For public traffic routes that are not possible sites for future targets, and for other exposures permitted at public traffic route distances from potential explosion sites, fragment and firebrand minimum distance for divisions 1.1 and 1.3 may be reduced to 60 percent of these requisite distances.

7. When determining inhabited building and public traffic route distances, use table 6-1 for class 1, division 1; table 6-2 for specified class 1, division 1, items; tables 6-6 through 6-9 for class 1, division 2; table 6-10 for class 1, division 3; and table 6-11 for class 1, division 4.

NOTES:

1. Distances are computed using the following factors:

NEW	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8
0 - 100,000	$35W^{1/3}$	$25W^{1/3}$	$40W^{1/3}$	$21W^{1/3}$	$15W^{1/3}$	$24W^{1/3}$
100,000 - 250,000	$0.3955W^{0.7227}$	$.004125W^{1.0898}$	$2.42W^{0.577}$	$.2375W^{0.7227}$	$.002475W^{1.0898}$	$1.452W^{0.577}$
250,000 - 15 million	$50W^{1/3}$	$50W^{1/3}$	$50W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$	$30W^{1/3}$

2. The policy contained in Chapter 6, subsection B.6., shall be employed for mass-detonating, fragment-producing items. *
3. The distance for 0 to 50 pounds may be used only when structures, blast mats, etc., can completely confine fragments and debris. Lesser distances may be used only if blast, fragments, and debris can be confined completely, as by certain test firing barricades.
4. Applies only to earth-covered magazines with dimensions of 26 feet wide and 60 feet long, or larger.

Table 6-1. Class 1, Division 1: Inhabited Building and Public Traffic Route Distances. (continued)

Table 6-2. Minimum Fragment Protection Distances for Selected Class 1, Division 1, Items.

Nomenclature	Distance Required in Feet			
Col 1	Col 2 1 Unit	Col 3 2 Units	Col 4 5 Units	Col 5 10 Units[2]
Bomb, 750 lb, M117A2	690	820	1020	1470
Bomb, 500 lb, Mk82	670	860	1080	1240
Projectile, 175mm, M437A2	450	580	830	2070
Projectile, 155mm, M107	400	510	720	1490
Projectile, 105mm, M1[1]	270	350	500	1000
Projectile, 8 in, Mk25	520	750	960	1240
Projectile, 5 in, Mk49	280	430	660	1000
Torpedoes (Navy) not over 1,500 lbs NEW[3]	500	500	500	500

[1] 105mm projectiles and 105mm complete rounds not in standard storage and shipping containers are class 1, division 1, ammunition.

[2] Ten units or more, until the distance in this table is exceeded by the distance requirements in table 6-1, column 3.

[3] Any torpedoes analogous, in terms of explosive hazard, to Mk16 war shot.

2. Distances in column 4 apply to nonstandard, earth-covered magazines oriented so that all straight lines between the side and rear walls of two magazines pass through an earth-covered surface of each; similarly, column 10 distances apply to all orientations in which every straight line between two magazines passes through the earth cover of one and only one of them. If the above conditions cannot be met, column 12 distances apply. The earth cover of nonstandard magazines must be equal to or greater than that required for standard earth-covered, arch-type magazines.

3. Other factors limiting igloo magazine storage are as follows:

* a. Igloo magazines that are equivalent in strength to those specified * under the definition of "magazine" in the definitions section of this Manual, * are limited to 500,000 pounds NEW. Igloo magazines, not equivalent in strength * to those, are limited to 250,000 pounds NEW. *

b. Quantities above 500,000 pounds NEW in one storage location are not authorized except for liquid propellants.

c. The distance given for 0 to 100 pounds NEW constitutes the minimum magazine spacing permitted.

* 4. Examples given in subparagraphs D.1.a.(1) through D.1.a.(5), above, * apply only to the storage of class 1, division 1, ammunition and explosives. Existing earth-covered magazines, regardless of orientation, meeting the con- * struction and barricading requirements of Chapter 4 and consistent with the * * definition of "magazine" in the definitions section of this Manual (and * sited for any quantity of class 1, division 1) may be used to their physical capacity for the storage of class 1, divisions 2, 3, and 4, A&E.

E. CLASS 1, DIVISION 2 (NONMASS-DETONATING, FRAGMENT PRODUCING)

1. Items in this division are those for which the principal hazards are fragment and blast, either individually or in combination, depending on such factors as storage configuration, type of packing, and quantity. The designated minimum distances that are specified are based on the limiting range of fragments for which protection by distance is to be provided and shall be used for inhabited building and public traffic route distances. Most fragments produced by incidents in this division will fall within one of the four specified minimum distances, that is, 400, 800, 1,200, and 1,800 feet.

2. The fragment hazard from items within a specified minimum distance category varies with existing conditions, but is essentially the same for one as for many items or components. For these items, the required separation distances are influenced heavily by packing, state of assembly, charge/weight ratio, and caliber. Items in this division usually explode progressively when involved in a fire or otherwise initiated. Therefore, the distances prescribed will not be lessened if the quantity to be stored is less than the maximum quantity specified by the appropriate table.

Table 6-6. Category (04), Class 1, Division 2.[1]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
No limit specifically required for safety reasons	400	240	200	200	(See note[2])

List of items (examples only): Small arms ammunition with explosive projectiles; 20mm ammunition with explosive projectiles; fixed ammunition with nonexplosive projectiles when caliber and packing limit the hazard in accordance with this class; WP smoke hand grenades; and nonmass-detonating CBUs[2].

[1]Limited quantities of items in this class, for reasons of operational necessity, may be stored in facilities such as hangers and manufacturing or operating buildings, without regard to Q/D. Examples: small destructors, fuzes, and firing devices.

[2]Earth-covered buildings may be used to their physical capacity for this category of material, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

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[2]Earth-covered buildings may be used to their physical capacity for this division, provided they comply with the construction and siting requirements of Chapters 4 and 6 for class 1, division 1, material.

[3]For determining distances to be used in event special requirements exist for * amounts above one million pounds or below one thousand pounds, the values given * above will be extrapolated by means of cube-root scaling as follows:

For inhabited building and public traffic route distances: $D=8W^{1/3}$
For aboveground magazine and intraline distances: $D=5W^{1/3}$
* As applicable, interpolation is allowed using 8 and $5W^{1/3}$. *

G. CLASS 1, DIVISION 4 (MODERATE FIRE, NO BLAST)

Items in this division present a fire hazard with no blast hazard and virtually no fragmentation hazard beyond the fire hazard clearance ordinarily specified for high risk materials. Separate facilities for storage and handling of this division should not be less than 100 feet from other facilities, except those of fire-resistive construction, which may be 50 feet from each other.

Table 6-11. Class 1, Division 4.[1, 2]

NEW	Inhabited Building Distance (feet)	Public Traffic Route Distance (feet)	Intraline Distance (feet)	Magazine Distance (feet)	
				Aboveground	Earth-covered
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
No limit specifically required for safety reasons	100	100(2)	Appropriate fire protection distance	50 (100 if combustible construction)	No specified separation requirement

List of items (examples only): Small arms ammunition without explosive projectiles, fuse lighters and squibs, distress signals, 20mm ammunition without explosive projectiles, colored smoke grenades, and explosive valves or switches.

[1]With reasonable care, class 1, division 4, items may be stored in an area for general supplies in any weatherproof warehouse, provided these warehouses storing division 4 ammunition are separated from all other warehouses by at least the aboveground magazine separation distance specified.

[2]Limited quantities of class 1, division 4, items may be stored in facilities such as hangars and manufacturing or operating buildings without regard to Q/D.
* Examples: small arms ammunition, riot control munitions, and pyrotechnics. *
* Also, small magazines used for similar purposes may be separated by applicable * fire protection distances.

3. All employees exposed to hazardous quantities of pyrotechnic compositions shall wear the additional items described in paragraphs 0.3.a. through 0.3.c., below, or their equivalent. The definition of hazardous quantities will depend on the composition's energy output and sensitivity (as determined by hazard analysis or tests) and the nature of the operation. Required levels of protective apparel will be specified in appropriate SOP steps. *

a. Aluminized, thermally protective suit with hood and face plate.
b. Aluminized, thermally protective trousers.
c. Aluminized, thermally protective gloves or equivalent.

4. When the items described above are required, the design and wearing will ensure that no areas of the body are exposed. Appropriate seals or joints will be used to preclude flame intrusion where apparel items overlap or are joined. Particular attention will be given to possible gaps in coverage provided by the hood in order to prevent flame or hot gas impingement on the face, head, or neck.

P. ADDITIONAL CONTROLS

1. Many materials used to produce pyrotechnics are toxic, represent fire hazards, or both. Operations will provide protection from these threats. Vapor- and dust-removal and collection systems must be provided where toxic or flammable dusts or gases are generated. Design and installation of such equipment must meet environmental as well as safety standards.

2. Blankets should be provided in easily opened containers within 25 feet of operations where they could be required for wrapping burned employees. Alternate means of achieving the same effect should be provided when blankets are not.

3. When required, conductive shoes will be checked for conductivity daily before the beginning of work. A log of the testing shall be maintained. *

Q. REWORKING PYROTECHNIC COMPONENTS

1. All repair, reassembly, or similar operations on loaded pyrotechnic compositions will take place in a separate bay used only for that purpose.

2. Consolidated or extruded pyrotechnic compositions will normally be destroyed, not pulverized for reblending. While HC smoke and such compositions are reusable, more sensitive materials, such as IR flare compositions, are not.

R. FIRE PROTECTION

When compatible with process materials, deluge systems may be used for the protection of mixing and blending operations, screening, granulation, drying, and pressing or extrusion operations. The response time of the deluge system should be selected to minimize the damage to process equipment and facilities. Hazard analysis of the operation may dictate other applications.

CHAPTER 10

FIRE PROTECTION

A. GENERAL

This chapter provides general standards for personnel developing and effecting fire protection and prevention programs in A&E environments.

B. FIRE PLAN

A written fire plan shall be prepared. Although details may vary, plans for all establishments shall itemize the emergency functions of each department or outside agency, indicating responsible individuals and alternates.

C. FIREFIGHTING AGREEMENTS

Voluntary and mutual agreements with nearby municipalities or industrial centers should include firefighting procedures as established by the plant officials. Plant officials are responsible for informing the assisting firefighters of particular procedures to be followed. Outside firefighters should not assist in fires involving A&E. If the practical need for their doing so can be anticipated, they shall receive advance instruction in A&E firefighting procedures. Outside firefighters shall never attack fires involving hazard classes 1.1 and 1.2.

D. SMOKING

Smoking may take place only in safe, specifically designated and posted "smoking locations."

1. Cigarettes, tobacco, and matches shall be discarded in ash receptacles only. They shall not be dropped into trash cans.

2. Electric lighters with automatic pressure cutoffs shall be fixed, ensuring against removal.

3. At least one fire extinguisher shall be provided at smoking locations.

4. Persons wearing clothing contaminated with explosives or other dangerous material should not be permitted in smoking areas.

E. PERMITS

A written permit shall be required for the temporary use of heat-producing equipment or devices when explosives or highly flammable materials are involved.

F. PORTABLE FIRE EXTINGUISHERS

Hand extinguishers within buildings can squelch incipient fires before major damage is done. Portable equipment may prove similarly valuable outside aboveground magazines and other buildings with explosives.

G. HAZARDS IN FIGHTING FIRES INVOLVING AMMUNITION AND EXPLOSIVES

A fire hazard identification system must be adopted. This shall assess relative dangers, up to the most hazardous material stored.

1. The following fire symbol system is provided as a guide:

a. Fire divisions, numbered "1" through "4," shall correspond to hazard classes 1.1 through 1.4.

b. The lower the number, the greater the hazard:

Fire Division	Hazard Involved
1	Mass detonation
2	Explosion with fragment hazard
3	Mass fire
4	Moderate fire

c. Distinctively shaped placards, instantly recognizable from a distance, signify the different divisions. Each placard, or symbol, shows the fire division number:

Shape	Fire Division
Octagon	1
Cross	2
Inverted triangle	3
Diamond	4

d. Black numbers appear on orange backgrounds as used by NATO, * UNO, IMO, and DOT. Reflectorized or luminous symbols are preferred. *

2. Firefighting Procedures

a. General

* (1) Fires should be immediately reported and may be fought without * specific authorization. However, personnel should evacute and seek safety if fires involve explosive materials, or cannot be controlled by equipment at hand. Training of operational personnel shall cover the characteristics of explosive materials, including their reactions to heat and fire, as well as what to do in case of fire.

(2) Firefighters should be thoroughly informed of the specific reactions of A&E exposed to heat or fire.

(3) Firefighters should be briefed on conditions at the scene before proceeding.

CHAPTER 11

SPECIFIC CHEMICALS

A. GENERAL

This section covers specific chemicals used during explosives manufacturing/processing and provides basic guidance for the establishment of local safety requirements. Publications listed below are acceptable as guides in the formulation of safety standards except where they conflict with the requirements of this Manual:

1. Chemical Data Sheets, National Safety Council.

2. Liquid Propellant Handling, Storage and Transportation, CPIA publication No. 194, dated 1970.

3. Patty's Industrial Hygiene and Toxicology.

4. Industrial Fire Hazards Handbook.

5. Dangerous Properties of Industrial Materials - Sax.

B. REPAIRS TO ACID EQUIPMENT

1. Before a pipeline, pump, or other equipment exposed to acid is dismantled for repairs, it should be drained and washed down with water. All pressure must be relieved; valves, switches, etc., must be tagged or locked to prevent the accidental application of pressure or the introduction of acid into the line. Branch lines where pockets may exist require particular attention. All pumping on the system connected with parts under repair should cease, with starters tagged and locked, unless blank flanges in the lines cut off the affected parts from the pump. In breaking a flange, the bottom bolts should be loosened first and the first line allowed to sag slightly, permitting the liquid to run out by gravity. Spilled liquid shall be disposed of properly after the repairs. Absent other information, chemical pipelines shall be assumed to contain liquid.

2. Repairing used-steel acid tanks presents two types of hazards. Even a trace of weak acid or weak acid sludge will violently react on the metal, generating gases. These could cause an explosion if welding is carried out on the tank. Personnel working inside the tank risk serious poisoning from the gases. Therefore, before repairs start, the tank shall be washed out, filled with water, then drained. If any acid remains, it may be necessary to apply soda ash solution and steam, then fill the tank with water, repeating the * original procedure. Before entering tanks, check that sufficient oxygen is * present. When someone is working inside the tank, an observer shall be present, with at least one other person available for rescue work, should the worker in the tank be overcome; such personnel shall receive training in tank rescue work. Those entering tanks shall have respiratory protective equipment, life belts, or harnesses and lifelines.

3. Neutralizing Spills. Slaked (hydrated) lime shall be available to neutralize spilled acid. A 10 to 20 percent solution of sodium bicarbonate will remove acid from floors or equipment. Because neutralization generates

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heat, care must be taken in cleaning large quantities of acid. Soda or other alkaline solutions shall neutralize all places made slippery by acid, which shall then be flushed with water.

4. Mixing Acid With Water. The acid shall be added to the water, never the water added to the acid, when significant amounts are being diluted. Acid should be added slowly with agitation. Weak acid replacing water as the diluting agent requires similar precautions. Solutions shall be thoroughly mixed, particularly in steel tanks.

5. Empty Containers. Carboys that have contained acids must be thoroughly drained before being offered for transportation. They will be shipped in the same manner as full items.

C. MIXED ACIDS

Mixed acids include mixtures of sulfuric and nitric acids used in the nitration of various explosives constituents. The pressure of liberated gases sometimes causes carboys of mixed acids to rupture violently. Mixed acids can start fires, generate gases that cause explosions, and emit poisonous oxides of nitrogen. Mixed acid containing not less than 10 percent of nitric acid will not freeze at ordinary temperatures and will not actively attack steel storage tanks.

D. WASTE ACIDS (SPENT ACIDS)

Waste acids usually contain small amounts of nitrobodies, so present the hazard of explosive material. Spent acid from the manufacture of nitroglycerin and liquid esters are particularly hazardous.

E. NITRIC ACID

Nitric acid forms explosive compounds with most organic materials. With most oxidizable material, it forms flammable compounds, some of which are subject to spontaneous ignition. Nitric acid fire creates exceedingly toxic oxides of nitrogen. Buildings where nitric acid is used must have proper ventilation. Enough space shall separate them to allow for firefighting forces; also, to prevent the accumulation of acid "fumes" (sometimes colorless, at other times identifiable, ranging from dark yellow to brown). The first symptoms of nitrous poisoning are usually followed by a latent period, when the victim feels comfortable though the poisoning continues. For this reason, anyone with even mild symptoms of nitrous poisoning must immediately * be made completely still and attended by a physician as soon as possible. *

F. SULFURIC ACID (OIL OF VITRIOL)

Concentrated sulfuric acid chars wood, cotton, and vegetable fibers, usually without causing fire, but oleum (fuming sulfuric acid) usually does cause fire in these materials. The addition of water may create heat sufficient to cause a fire or explosion, and greatly increases the corrosive properties of oleum. This does not preclude the use of large quantities of water to dilute or dissipate small quantities of acid. Sulfuric acid must not be stored with nitric acid, volatile or flammable liquids, or oxidizing

CHAPTER 12

SAFETY STANDARDS FOR EXPLOSIVES FACILITIES

A. GENERAL

This chapter contains minimum safety standards for existing, new, or modified explosives facilities and equipment. For facilities primarily used * for general industrial operations, the standards of this chapter shall apply * in areas performing low-volume explosives work.

B. STANDARDS

Special properties of materials and operational hazards may require that national, Federal, and local standards be exceeded. In such cases, standards in this chapter will apply.

C. STANDARDS FOR BUILDINGS

1. Building Exteriors. Exterior wall and roof coverings of operating buildings should be noncombustible and, whenever possible, frangible, of "breakaway" construction. The buildings should have no basements and should not exceed one story, except to meet process requirements.

2. Interior Walls, Roofs, and Ceilings. Interior wall surfaces and ceilings of operating buildings which might house loose, finely divided explosives materials shall be smooth, free from cracks and crevices, fire resistive and, if painted, be covered with high-gloss paint, to minimize dust accumulation and facilitate cleaning. As further protection against dust, ledges should be avoided; any that exist shall be beveled or kept clean. Wall joints and openings for wiring and plumbing shall be sealed against dust. Roofs and walls should be as light as practicable, constructed and supported to * vent an internal explosion with the formation of few large fragments. Firewalls * and dividing walls constitute exceptions. When class II hazard locations exist as defined by the National Electric Code (NEC) (reference (j)), suspended ceilings and hollow walls are prohibited in explosives facilities. Recommended practice is to install insulation and covering directly on the underside of the roof deck.

* 3. Floors and Work Surfaces. Floors and work surfaces shall be constructed * to facilitate cleaning, with no cracks or crevices in which explosives could lodge. Nonsparking floors and work surfaces are required in all locations where exposed explosives or hazardous concentrations of flammable vapor or gas are present. When grounding is necessary, conductive floors (mats or similar static-dissipating floor surfaces), tabletops, and other work surfaces shall be provided. Cove bases at the junctions of walls and floors are preferred. No exposed nails, screws, or bolts in work surfaces shall be permitted.

4. Substantial Dividing Wall

a. Substantial dividing walls, constructed in accordance with the requirements of TM 5-1300 (reference (d)), separate independent concentrations

of high explosives so they do not need to be added when determining Q/D requirements.

b. Openings in dividing walls for conveyors, pass-through boxes, or other uses, should be avoided. However, in locations where operationally necessary, the following apply:

(1) The opening(s) will not be larger than the minimum needed for the material's safe passage.

(2) Closures shall have equivalent wall strength characteristics and fusible links.

5. Exits and Doors. No explosives hazard shall occupy space between an operator and an exit. Exit doors in buildings containing explosives, except storage magazines, should be casement-type and glazed with nonshatterable plastic material. All interior doors should open in the direction of the flow of material through the building and should open onto unobstructed passageways.

6. Emergency Egress. When standard exits and fire escapes do not provide for rapid enough egress from work levels above the ground floor, other means of emergency egress (that is, safety chutes) shall be provided.

7. Passageways. Weather-protected passageways between buildings or magazines should be of noncombustible construction and equipped with fire stops to interrupt a fire's progress.

8. Roads and Walkways. Good all-weather roads should be provided. Only roads serving a single magazine or explosives processing building (including its service facilities) may dead end, and then, only at the magazine or building. The road system should be designed to make it unnecessary to pass through an explosives area to travel from one place to another. Walkways and roads at the entrance to or between adjacent buildings containing explosives should be boardwalks or hard surfaced, preventing employees from tracking stones, grit, and other foreign material into operating buildings.

9. Windows and Skylights. Nonshatterable glazing is preferred where an explosion accompanied by falling or projected glass could cause injury. When glazing with conventional glass is used, the hazard may be reduced by covering it with properly fixed plastic or wire mesh screening.

10. Drains and Sumps

a. All drain lines handling explosive wastes shall have sumps or basins of sufficient capacity for the removal of explosives by settling. The drains shall be of adequate capacity; free of pockets; and with slopes of at least one-quarter inch per foot to prevent explosives settling-out in the drain line, rather than in the sump or settling basin intended to collect them. Sumps shall be so designed that suspended and settleable solid explosive material cannot be carried beyond the sumps in the wash waters, and so overflow will not disturb any floating solids. The settling rate of the material and the usual rate of flow shall be taken into account in determining the sump's capacity.

(2) On the outside walls of buildings considered hazardous locations.

b. Limit switches, pressure switches, float switches, and any other control devices which for practical operating reasons cannot be located outdoors shall bear the approval of the Underwriters' Laboratories, Inc., or other * nationally recognized testing agencies. Electrical conduit connections to such * equipment shall comply with the requirements of the latest edition of the NEC (reference (j)) for the specific hazard.

c. The primary electric supply to an entire explosives area should be so arranged that it can be cut off by switches located at one or more central points away from the area.

6. Flashlights and Lanterns. Flashlights and hand lanterns powered by low-voltage dry cell batteries and miners' cap lamps, approved as "Permissible" by the United States Bureau of Mines or, for class I hazardous locations, by * Underwriters' Laboratories, Inc., or other nationally recognized testing agencies, * may be used in both class I and class II hazardous locations.

E. LIGHTNING PROTECTION

* When installed, lightning protection systems shall be in accordance with * the NFPA Lightning Protection Code (reference (i)) at a minimum.

F. STATIC ELECTRICITY AND GROUNDING

1. Detailed discussions of the hazards of static electricity and ways of reducing it are published by the National Fire Protection Association, Underwriters' Laboratories, Inc., the United States Department of Commerce, and the Bureau of Mines, U.S. Department of the Interior. Where static spark discharge may be hazardous, NFPA 77, "Static Electricity" (reference (i)) shall apply, except as otherwise specified herein.

2. Grounding of Equipment. Bonding straps shall bridge contact points where oil, paint, or rust could disrupt electrical continuity. Permanent equipment in contact with conductive floors or tabletops is not considered adequately grounded. Static grounds shall not be made to gas, steam, or air lines, dry pipe sprinkler systems, or air terminals of lightning protection systems. They may be made to water pipes, ground cones, buried copper plates, driven ground rods, or to down-conductors of lightning protection systems. All grounds must be interconnected if a structure is equipped with a lightning protection system. Metallic bonding and grounding cables, straps, or clamps shall be compatible with the explosives being processed.

3. Belts. Conductive belting shall be used wherever static is a hazard. Such belting shall have a resistance to ground not exceeding 600,000 ohms. Static combs must not be used to drain off static generated from belting or pulleys used in the presence of hazardous concentrations of explosives dust or flammable vapors.

4. Testing Equipment Grounds. Grounding systems shall be tested for electrical resistance and continuity when installation has been completed and, in the case of active equipment, at locally determined intervals.

The ground systems of equipment inactive longer than 1 month shall be visually inspected for resistance and continuity before reactivation. All exposed explosive or hazardous materials shall be removed before testing. All test records should be kept. In ground-resistance testing, equipment should be considered as a unit. All conductive parts of equipment shall be grounded so that resistance does not exceed 25 ohms, unless 10 ohms is required for lightning protection. To ensure compliance with ohmic requirements, resistance of the belting is to be excluded in measuring the total resistance to ground for belt-driven machinery. The rate of static generation should be considered before changes in grounding systems are made.

5. Conductive Floors. Conductive floors and conductive shoes shall be used for grounding personnel at operations with exposed explosives with electrostatic sensitivity of 0.1 joule or less, such as primer, initiator, detonator, igniter, tracer, and incendiary mixtures. Materials sensitive to static sparks, easily ignited or detonated, include lead styphnate, lead azide, mercury fulminate, tetrazene, diazodinitrophenol, potassium chlorate-lead styphanate mixtures, igniter compositions, grade B magnesium powder, and exposed layers of black powder dust. Dust from solid propellants can be ignited from spark energy, making conductive floors and shoes necessary where such dust is present. Air and dust mixtures of ammonium picrate, tetryl, tetrytol, and solid propellants are also sensitive to static electricity discharge. Many flammable liquids and air mixtures tested (ethyl ether, ethyl alcohol, ethyl acetate, acetone, and gasoline) can be ignited by human static discharge. Therefore, areas where personnel might come into contact with the kinds of explosives or mixtures enumerated above shall be equipped with conductive floors, except when the hazards of dust/air or flammable vapor/air mixtures are eliminated by adequate housekeeping, dust collection, ventilation, or solvent recovery methods.

a. Conductive floors are also required when operations involve the following:

(1) Loose, unpacked ammunition with electric primers.

(2) Exposed electro-explosive devices such as squibs, detonators, etc.

(3) Electrically initiated items, such as rockets, with exposed circuitry.

(4) Hazardous materials that could be ignited by human static discharge.

b. When a hazard remains localized, conductive floors and footwear are not required throughout an entire building or room. In such cases, conductive mats or runners may be used. These mats and runners must meet all the specifications and test requirements that apply to conductive floors.

6. Conductive Floor Specifications. Conductive floors, made of nonsparking materials such as lead, conductive rubber, or conductive flooring compositions, shall meet the following requirements:

a. The flooring and its grounding system must provide for electrical resistance not to exceed 1 million ohms.

2. Personnel shall wear clothing that prevents generation of static electricity. Conductive shoes shall be tested with a resistance meter before an operator enters an area where low-energy initiators are being processed.

3. When low-energy initiators are being handled, personnel shall be directly grounded by wrist straps. The resistance reading, taken once daily * when the operator is wearing the strap, shall be between 250,000 and one million * ohms when measured from opposite hand to ground. Special contact creams may be used to decrease the resistance to the required value.

4. Glass, acrylic, or polycarbonate materials required for transparent shielding shall be periodically coated with an antistatic material to prevent buildup of static electricity.

5. The sounding of a static electricity alarm, installed with the setting best able to provide ample warning, signals that work shall stop until the problem has been located and corrective action taken.

6. Work will not start in air-conditioned areas until relative humidity * and temperature have been checked (see Chapter 12, subsection F.8.). *

7. No metal surface subjected to rubbing or friction shall be painted. If a lubricant is necessary, it should be of a composition that will not increase the metal's surface resistance above 25 ohms.

8. Work on or with initiators shall be performed in areas equipped with conductive floors and tabletops. Exceptions may be made when the initiators are in their original packaging, or are part of a finished metallic end item affording them complete protection from electromagnetic or electrostatic energy.

9. Work will not be done in the vicinity of actual or potential electromagnetic or electrostatic fields. Sources of static electricity and electromagnetic energy include radio transmission, electrical storms, transformer stations, high voltage transmission lines, improperly grounded electric circuitry, rotating equipment, belts, etc. Adequate lightning protection and grounding and adequate resistances for fixed sources of energy shall be established for locations with low-energy initiator operations. These shall be shielded to afford protection against local mobile radio transmission.

10. Electrical equipment shall be located out of the range of an operator working with a low-energy initiator. With soldering irons, it may be advisable to ground and limit energy to levels below initiating thresholds.

11. When not part of an end item or end item subassembly, initiators shall be transported only when packed according to the latest packing specifications for low-energy initiators.

* D. LABORATORY OPERATIONS *

1. Research and development laboratories and testing facilities constitute a separate category involving guidance, restrictions, and the waiving of certain requirements prescribed in this Manual.

2. Each operation at blast and fragment confinement facilities shall be reviewed to ensure that the explosives limits are within the laboratory or test area capability prescribed in this Manual. Facilities shall completely confine blast and fragment hazards, eliminating the need for public traffic route and inhabited building distances. Explosives limits and safe separation distances must be adjusted as the capability to confine fragment and blast decreases.

3. A total-confinement facility must be inspected after a detonation to ensure structural integrity, possibly reducing the explosives limits to prevent future blasts from exceeding the retention capability.

4. Each proposed program for the laboratory or test facility shall be reviewed to determine all potential hazards. Considerations shall include:

a. Structural limitations of the facility.

b. Remote control viewing and operating equipment, if required.

c. Special safety precautions for personnel elsewhere in the building.

d. Safe separation distances.

e. Required deviations from other parts of this Manual.

f. SOPs, which shall at a minimum include the following:

(1) Protective clothing.

(2) Warning signals.

(3) Fire and other emergency procedures.

(4) Special testing of equipment needed before operations (such as stray voltage and calibration checks).

(5) Removal of all explosives not needed for the operation.

(6) Arrangements for overnight storage of necessary explosives.

(7) Inspection and cleanup procedures after a test or detonation.

5. Laboratories shall use no more explosives than absolutely required for a given operation. Particularly hazardous laboratory operations involving new or relatively unknown explosives should be done by remote control. Operational shields shall be used in these operations and in new or untested applications of explosives.

* 6. When laboratories and testing facilities are shielded properly to prevent the release of fragments, the following applies: *

a. The minimum incremental safe separation distances of tables 13-1 and 13-2 shall apply to operations, facilities, and personnel of the establishment except as indicated in paragraph D.6.b., below.

CHAPTER 15

COLLECTION AND DESTRUCTION STANDARDS FOR AMMUNITION AND EXPLOSIVES

A. GENERAL

This chapter provides safety standards for the collection and destruction of ammunition and explosives.

B. PROTECTION DURING DISPOSAL OPERATIONS

1. Operational shields and special clothing shall protect personnel in facilities with explosives materials. Fragmentation hazards require, at a minimum, overhead and frontal protection for personnel. Shelters should be located at the inhabited building distance appropriate for the quantity and type of materials being detonated. Personnel shall use such protective measures when destroying explosive materials by detonation and when burning explosive materials that may detonate. Personnel shall not approach the burning site, but shall wait until the fire is out.

2. Personnel shall never work alone during disposal and destruction operations. Warning signs or roadblocks shall restrict the area. One person, available in an emergency, should observe from a safe distance while another performs the operations.

C. COLLECTION OF AMMUNITION AND EXPLOSIVES

1. Water-Soluble Materials. Enough water should be used in neutralizing ammonium picrate (explosive D), black powder, and other soluble materials to ensure their complete dissolution. As little material as practicable should be dissolved at one time. Sweeping floors before washing them down reduces the amount of dissolved material in the wash water. When uncertainty exists concerning the purity and composition of wash water, experts shall be consulted.

2. Solid Wastes. Explosives-contaminated solid waste material shall be collected; placed in closed containers; and swiftly removed to buildings for treatment or holding, or to the burning ground for destruction.

3. Explosives Dusts

a. High explosives dusts such as TNT, tetryl, explosive D, composition B, and pentolite should be removed by a vacuum system. A "wet collector" that moistens the dust near the point of intake and keeps it wet until the dust is removed for disposal is preferred for all but explosive D, which should be collected in a dry system.

b. More sensitive explosives such as black powder, lead azide, mercury fulminate, tracer, igniter, incendiary compositions, and pyrotechnic materials may be collected by vacuum, provided they are kept wet close to the point of intake. Collect each type, representing a different hazard, separately, so that black powder, for example, cannot mix with lead azide. Provision should be made for releasing any gases that form. The use of vacuum systems for collecting these more sensitive materials should be confined to operations involving small quantities of explosives, that is, operations with fuzes,

detonators, small-arms ammunition, and black powder igniters. To minimize the fire and explosion hazard, collection of scrap pyrotechnic, tracer, flare, and similar mixtures in No. 10 mineral motor oil or equivalent is required. Materials collected in the dry state shall be placed in an oil-containing * receptacle available at each operation throughout the shift. The oil level * should be about 1 inch above the level of any pyrotechnic mixture in the * container. Containers of scrap explosive shall be removed from the operating * * buildings for disposal at least once per shift. Applicably rated class B * firefighting equipment shall be available when oil is used.

4. Design and Operation of Collection Systems

a. Collection systems and chambers shall be designed to prevent pinching thin layers of explosives or explosives dust between metal parts. Pipes or ducts used to convey dusts require flanged, welded, or rubber connections. Threaded connections are prohibited. The system shall prevent explosives dusts from accumulating in parts outside the collection chamber. Pipes or ducts conveying high explosives shall have long radius bends. Systems for propellent powder may use short radius bends provided they are stainless steel, with polished interiors. Vacuum application points should be kept to a minimum. Each room requiring vacuum collection should have a separate exhaust line to the primary collection chamber; if this is not possible, no more than two bays shall be serviced by a common header. Wet primary collectors are preferred. The length of vacuum line from points of application of vacumm to the wet collectors should be short. A single secondary collector shall service as few primary collectors as possible. Not more than two dry primary collectors shall be connected to a single secondary collector (wet or dry type). If an operation does not create a dust concentration potentially posing a severe health hazard, manual operation of the suction hose to remove explosives dust is preferred, since permanent attachment to the explosive dust-producing machine increases the likelihood of propagation through the collection system of a detonation at the machine. Manually operated hose connections to explosives dust-producing machines should not interconnect.

* b. Two collection chambers shall be serially installed ahead of the * pump or exhauster to prevent explosives dust from entering the vacuum producer in a dry vacuum collection system.

* c. Slide valves for vacuum collection systems are permitted; however, * * there shall be no metal-to-metal contact. An aluminum slide operating between * two ebonite spacer bars or similar, compatible materials will eliminate unacceptable metal-to-metal contact.

d. Dry-type portable vacuum collectors, limited to five pound of explosives, will be located in a separate cubicle having substantial dividing walls, or outside the building; never in a bay or cubicle with explosives. Wet-type portable vacuum collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collector is limited in accordance with the requirements of paragraphs C.5.a. through c., below. For dry collection of quantities in excess of five pounds or wet collection of quantities in excess of 15 pounds, the provisions of paragraphs C.5.a. through c., below, also apply.

e. The design of wet collectors shall provide for proper immersion of explosives, breaking up air bubbles to release airborne particles; and for removal of moisture from the air leaving the collector, to prevent moistened particles of explosives from entering the small piping between the collector and the exhauster or pump.

f. At least once every shift, explosives dust shall be removed from the collection chamber to eliminate unnecessary and hazardous concentrations of explosives. The entire system should be cleaned weekly, with parts dismantled as necessary.

g. The entire explosives dust collecting system shall be electrically * grounded. The grounding shall be tested on a locally determined schedule. *

h. Small vacuum systems positioned close to work stations shall be shielded.

5. Location of Collection Chambers

a. Whenever practicable, dry-type explosives dust collection chambers, except portable units, shall be located in the open, outside operating buildings, or in buildings set aside for the purpose. To protect operating personnel from blast and fragments from the collection chamber, a barricade or operational shield appropriate for the hazardous quantities involved, shall be provided between the operating building and the outside location or separate building housing the collection chamber. At least 3 feet shall separate the collection chamber from the barrier wall.

b. When locating dry-type collection chambers outside the operating building is not feasible, a separate room shall be set aside for this purpose in the building. This room shall neither contain other operations nor be used as a communicating corridor or passageway between other operating locations when explosives are being collected. Walls separating the room from other portions of the operating building shall meet the requirements for operational shields for the quantity of explosives in the collection chamber. If more than one collection chamber is to be located in the room, the room shall be subdivided into cubicles, with only one collection chamber per cubicle.

c. Stationary and portable wet-type collectors may be placed in explosives operating bays or cubicles, provided the quantity of explosives in the collectors does not exceed five pounds. Placed in separate cubicles, quantities may increase to 15 pounds. For wet collectors containing more than 15 pounds, location requirements set forth in paragraphs C.5.a. and b., above, apply.

d. Explosives/Munitions Awaiting Destruction. Material awaiting destruction when stored in the open shall be inhabited building distance from explosives being destroyed. Provided with adequate frontal and overhead protection, material awaiting destruction may be stored at intraline distance from the explosives being destroyed. All such material shall be protected against accidental ignition or explosion from ambient storage conditions or from fragments, grass fires, burning embers, or blast originating in materials being destroyed.

7. Containers for Waste Explosives. Containers for these explosives shall be the original closed packages or equivalent. Closures shall prevent spillage or leakage of contents when handled or overturned, and must not pinch * or rub explosives during closing and opening. Containers shall be marked clearly * * to identify contents. No containers constructed from spark-producing or easily * ignited material shall be used.

D. DESTRUCTION SITES

1. Site Criteria

a. Destruction of ammunition and explosives shall occur as far as possible from magazines, inhabited buildings, public highways, runways, taxi- * ways, and operating buildings. Separation distances shall be at least 1,250 * * feet or the applicable fragmentation distance unless pits or similar aids * * limit the range of fragments. Natural barricades shall be used between the * site and operating buildings or magazines. The possibility that the explosives may detonate when being burned requires use of appropriate protective barriers or separation distances for the safety of personnel and property. Explosives shall not be burned or detonated on concrete, nor in areas having large stones or crevices.

b. In all disposal and destruction activities, the number of A&E units * or the explosives quantity that may be destroyed safely at one time shall be * * predetermined consistent with safe and efficient operations. *

c. Firefighting equipment should be available to extinguish grass fires and to wet down the area between burnings and at the close of operations.

d. Ordinary combustible rubbish should not be disposed of near areas where explosives and explosives-contaminated material are destroyed.

2. Material and Equipment Usage

a. Detonation of ammunition or explosives should be initiated by electric blasting caps, using blasting machines or permanently installed electric circuits energized by storage batteries or conventional power lines. When items to be detonated are covered with earth, the initiating explosives should be primed with enough primacord to allow connecting the blasting cap above ground level.

b. Special requirements for using electric blasting caps and electric blasting circuits follow.

(1) The shunt will not be removed from the lead wires of the blasting cap until the moment of connection to the blasting circuit. If the shunt must be removed to test the blasting cap before priming the charge, short circuit the lead wires again following the test by twisting the bare ends of the wires together. The wires will remain short circuited in this manner until the moment of connection to the blasting circuit.

(2) When uncoiling the leads of blasting caps, the following shall apply:

* I. SUPPORT IN DISPOSAL OF WASTE *

If Government-owned ammunition items or explosives are declared excess or residual and the contract says nothing about disposition, the contractor must * request instructions from the responsible Contract Administration Office. A * contractor having trouble safely disposing of residual (scrap) ammunition items or explosives related to contractual operations may request help from the * Contract Administration Office. *

DEPARTMENT OF DEFENSE
PUBLICATION SYSTEM

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(Force Management and Personnel)

CHANGE NO. 2
DoD 4145.26-M
April 11, 1988

DOD CONTRACTORS' SAFETY MANUAL
FOR
AMMUNITION AND EXPLOSIVES

The Assistant Secretary of Defense (Force Management and Personnel) has authorized the following page changes to DoD 4145.26-M, "DoD Contractors' Safety Manual For Ammunition and Explosives," March 1986:

PAGE CHANGES

Remove: Foreword and pages 6-1 through 6-4

Insert: Attached replacement pages and new pages 6-3a&6-3b.

Changes appear on the foreword, pages 6-1&6-2, and 6-3, and are indicated by marginal asterisks.

EFFECTIVE DATE

The above changes are effective immediately.

James L. Elmer

JAMES L. ELMER
Director
Correspondence and Directives

Attachments: 4 pages

WHEN PRESCRIBED ACTION HAS BEEN TAKEN, THIS TRANSMITTAL SHOULD BE FILED WITH THE BASIC DOCUMENT

SD FORM 106-2
81 MAR

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-4000

FORCE MANAGEMENT
AND PERSONNEL

FOREWORD

This Manual is issued under the authority of and in accordance with DoD Instruction 4145.26, "DoD Contractors' Safety Requirements for Ammunition and Explosives," July 19, 1985. The Manual provides safety standards common to DoD *and private industry ammunition and explosives (A&E) operations and facilities. * *The explosives safety requirements for DoD are set forth in DoD 6055.9-STD which* *serves as the primary source document for this Manual, and provides the minimum * *acceptable standards for quantity distances. The explosives safety requirements* *included in this Manual will remain consistent with DoD 6055.9-STD so that com- * *pliance by a DoD Component and a DoD contractor is essentially equal. *

The application of this Manual to A&E contracts is required by DoD FAR Supplements. Additional A&E or other related safety requirements may be included within the contract by the purchasing activity as determined necessary.

This revision includes basic principles of A&E safety, reduces mandatory requirements to the minimum, excludes safety requirements of other Federal regulatory agencies, and provides sufficient information to enable the contractor to make appropriate and reliable decisions affecting his or her facilities and operations. The methods of compliance are the responsibility of the contractor.

Questions on interpretation of any aspect of this Manual or recommendations for revisions by the contractor shall be submitted to the contractor's assigned administrative contracting officer (ACO) for further review and processing.

This Manual applies to the Office of the Secretary of Defense (OSD), Military Departments, Organization of the Joint Chiefs of Staff (OJCS), Unified and Specified Commands, and Defense Agencies (hereafter referred to collectively as "DoD Components").

This Manual is effective immediately, and is mandatory for use by all DoD Components specified in DoD Instruction 4145.26.

Forward recommended changes to this Manual through appropriate channels to:

Commander
US Army Armament, Munitions, and Chemical Command
ATTN: AMSMC-JS
Rock Island, IL 61299-6000

DoD Components may obtain copies of this Manual through their own publications channels. Other Federal Agencies and the public may obtain copies from the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Grant S. Green, Jr.

#First Amendment (Ch 2, 4/11/88)

CHAPTER 6

HAZARD CLASSIFICATION AND Q/D CRITERIA

A. GENERAL

1. This chapter outlines Q/D requirements applicable to storage, processing, and handling of A&E. The maximum amount of explosives permitted at any location is determined by the prevailing distance from that location to other exposures and the applicable Q/D table in this chapter. Greater distances than those shown in the tables should be used when practicable.

* 2. Distances required in the standard Q/D Tables may be reduced if * structural data/engineering demonstrate that explosion effects will be * reduced or eliminated through containment, direction/suppression shields * or building volume. The rationale or test results justifying the proposed * distance reduction must accompany A&E site and general construction plans when submitted through the ACO for the PCO's approval. (See Chapter 1, Section F.).

B. HAZARD CLASSES AND CLASS DIVISIONS

1. The hazard classification system is based upon the system recommended for international use by the United Nations Organization (UNO), consisting of nine classes for dangerous goods with ammunition and explosives included in UNO's "Class 1, explosives."

2. The A&E hazard classes are further subdivided into "divisions" according to the associated hazards, including the potential for causing personnel casualties or property damage. The list of items for each division contains examples; it is not all-inclusive.

3. The separation of the A&E hazard classes into the several divisions does not necessarily mean that the different items in a division may be stored together. Also, some items may appear in more than one division, depending upon factors such as the degree of confinement or separation, type of packaging, storage configuration, or state of assembly.

4. The maximum amount of explosives permitted in any location is limited by the Q/D criteria. Explosives limits shall be established in amounts no greater than those consistent with safe and efficient operations.

* 5. Class 1 is divided into the following divisions that indicate the type * of hazards expected:

Hazard Class and Division

Designators	Hazards
1.1	Mass detonating
1.2	Nonmass detonating Fragment producing

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1.3	Mass fire
1.4	Moderate fire, no blast
1.5	Insensitive high explosives

6. A numerical figure (in parentheses) is used to indicate the minimum separation distance (in hundreds of feet) for protection from debris, fragments, and firebrands when distance alone is relied on for such protection. This number will be placed to the left of the division designators 1.1 through 1.3, such as (18)1.1, (08)1.2, and (06)1.3. These numbers can be normally found in the explosive hazard component safety data sheets and are derived from the DoD Explosives Hazard Classification Procedures. A minimum distance as shown in applicable tables will be used for all items in division 1.2. The following apply to minimum fragment distances:

a. Minimum fragment distance for a particular ammunition/explosives item is based on the range to which a hazardous fragment density may be created by an explosion of the particular item involved. A hazardous fragment is one having an impact energy of at least 58 ft.-lb and a hazardous fragment density is constituted by at least one hazardous fragment impacting in an area of 600 square feet or less. Fragment distances do not indicate the maximum range to which fragments may be projected.

b. For divisions 1.1 and 1.3, a minimum distance number will be used where the ranges of hazardous fragments and firebrands EXCEED the distances specified for inhabited buildings in the applicable Q/D table.

c. Minimum fragment distance protects personnel in the open; minimum firebrand distance primarily protects facilities.

d. Examples where minimum fragment and firebrand distances for divisions 1.1 and 1.3 need not be applied follow:

(1) Recreation or training facilities, if these facilities are for the exclusive use of personnel assigned to the PES.

(2) Between PES and relatively static inert storage areas.

(3) Between facilities in an operating line, between facilities and holding sites in an operating line, between operating lines, and between operating lines and storage locations normally separated by inhabited building distances to protect workers and ensure against interruption of production.

e. The minimum distance for protection from hazardous fragments will be based on the debris producing characteristics of the PES and the population density of the ES. For populous locations, the minimum distance will be that distance at which fragments, including debris from structural elements of the facility or process equipment, will not exceed a hazardous fragment density of one hazardous fragment per 600 square feet ($56m^2$). If this distance is not known, the following shall apply:

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* (1) For all division 1.1 A&E the minimum distance to exposures * will be 670 feet for 100 pounds NEW or less. In quantities of 101 to 30,000 * pounds NEW, the minimum distance will be 1,250 feet. The above distances may * be reduced when it can be shown by test data that reductions are warranted or * when other alternatives, as described in paragraphs B6f thru B6i, below, are * utilized. For items that have been evaluated adequately, different minimum * distances, as in table 6-2, may be used. (Facilities sited at 1,235 or 1,245 feet in accordance with past standards will be considered to be in compliance with the 1,250 foot minimum requirement.)

* (2) For public traffic routes that are not probable sites for * future construction, and for other exposures permitted at public traffic route * distances from PES, fragment and firebrand minimum distances for divisions 1.1 and 1.3 may be reduced to 60 percent of these requisite distances.

* f. For sparsely populated locations on or off the establishment, * the minimum fragment distance can be reduced to 900 ft. if certain specific * conditions exist as follows:

* (1) No more than 25 persons are located in any sector bounded by * the sides of a 45 degree angle, with the vertex at the PES, and the 900 ft. * and 1,250 ft. arcs from the PES, and

* (2) The NEW of the PES does not exceed 11,400 pounds. *

* g. Minimum fragment distances may extend onto uninhabited areas such * as wildlife preserve, desert, prairie, swamp, forest or agricultural land, * adjacent to contractor facilities but not within control of the contractor. * However, without a restrictive easement in effect, construction of inhabited * buildings or other exposures in these areas, would reimpose minimum fragment * distance. *

* h. In lieu of the minimum fragment distances prescribed, other * alternatives, which reduce or eliminate the fragment hazard, may be used for * standards compliance, per paragraph A2. Examples include:

* (1) Use distance demonstrated by testing, accident experience or * engineering studies. *

* (2) Use protective structures. *

* (3) Use containment facilities or suppressive shields or other * fragment control devices. *

* (4) Design/locate equipment to reduce fragment generation or to * control the direction of fragmentation. *

* (5) Use barricades or terrain where possible to stop low angle, * high velocity fragments. *

* i. Fragment distance need not be applied when it is demonstrated by * structural analysis, sheilding test or other documentation that building * construction and volume will confine fragments and debris resulting from an * explosives accident. *

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7. When determining inhabited building and public traffic route distances, use table 6-1 for class 1, division 1; table 6-2 for specified class 1, division 1; tables 6-6 through 6-9 for class 1, division 2; table 6-10 for class 1, division 3; and table 6-11 for class 1, division 4.

8. When determining intraline and intermagazine distances, use tables 6-3 through 6-5 for class 1, division 1; tables 6-6 through 6-9 for class 1, division 2; table 6-10 for class 1, division 3; and table 6-11 for class 1, division 4.

9. In the application of inhabited building and public traffic route distances, table 6-1, the property boundary will be treated as the governing * target. In interpreting application to navigable waterways as public traffic * routes, occasional small fishing and pleasure boats may be ignored.

C. CLASS 1, DIVISION 1 (MASS DETONATING)

Entire quantities of items in this division can detonate almost instantaneously. Some examples: bulk explosives, some propellants, mines, bombs, * demolition charges, torpedo and missile warheads, rockets, palletized projectiles loaded with TNT or Composition B, 8-inch and larger high-capacity projectiles loaded with Explosive D, mass-detonating CBUs, and mass-detonating ammunition components. *

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NEW Over	Not Over	Distance in Feet to Inhabited Building From			Distance in Feet to Public Traffic Route From		
		Standard Earth-Covered Magazine		Other PES	Standard Earth-Covered Magazine		Other PES
		Front or Side	Rear		Front or Side	Rear	
1	2	3	4	5	6	7	8
0	1	35	25	40	21	15	24
1	2	44	32	50	26	19	30
2	5	60	43	69	36	26	40
5	10	75	54	87	45	32	52
10	20	95	68	110	57	41	65
20	30	110	78	125	65	47	75
30	40	120	86	140	72	51	83
40	50	130	92	150	77	55	89
50	100	160	115	190	97	70	115
100	200	205	145	235	125	88	140
200	300	235	165	270	140	100	160
300	400	260	185	295	155	110	175
400	500	280	200	320	165	120	190
500	600	295	210	340	175	125	205
600	700	310	220	355	185	135	215
700	800	325	230	375	195	140	225
800	900	340	240	390	205	145	235
900	1,000	350	250	400	210	150	240
1,000	1,500	400	285	460	240	170	275
1,500	2,000	440	315	505	265	190	305
2,000	3,000	505	360	580	305	215	350
3,000	4,000	555	395	635	335	240	380
4,000	5,000	600	430	685	360	255	410
5,000	6,000	635	455	730	380	275	440

Table 6-1. Class 1, Division 1: Inhabited Building and Public Traffic Route Distances.